GENERAL REPORT

On the operations of

SURVEY OF INDIA

1895-86 and 1886-87

~~1905-06.~~

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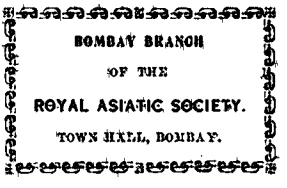

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GENERAL REPORT

ON THE

Operations of the Survey of India Department,

ADMINISTERED UNDER THE GOVERNMENT OF INDIA

DURING

1885-86. & 1886-87

PREPARED UNDER THE DIRECTION OF

LIEUTENANT-COLONEL H. R. THUILLIER, R.E.,

OFFICIATING SURVEYOR GENERAL OF INDIA.

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1886.

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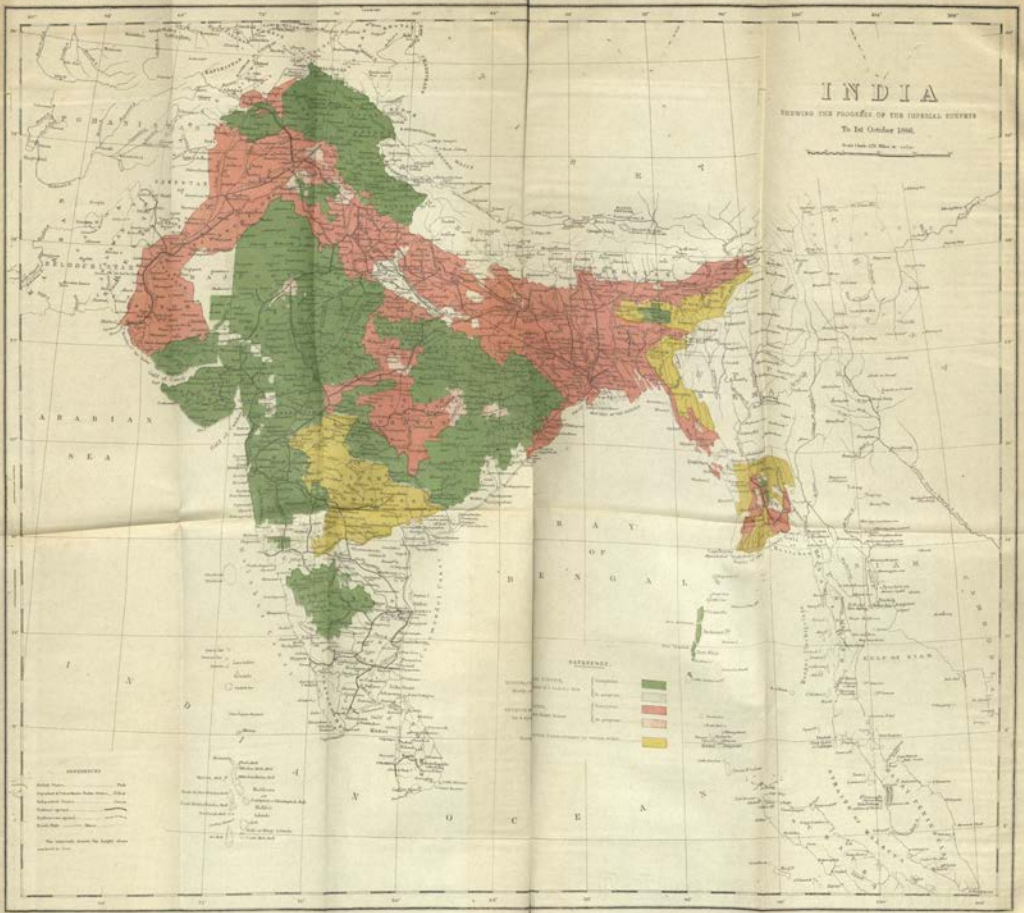

Published under the direction of Lieut. Colonel H. S. Thuillier, R.E., Officiating Surveyor General of India,
Survey of India Office, Calcutta, February 1867.

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OF
INDIA
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CEYLON

Correction for Annual Report, Season 1884-85.

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GENERAL REPORT

ON THE

Operations of the Survey of India,

DURING THE SURVEY YEAR

1885-86.

PART I.

INTRODUCTORY.

The operations of the Survey parties, and the work in the several branches of the Head-quarter Offices of the Survey of India, which are now reported upon, are for the year ending 30th September 1886.

2. The general direction of the Department and the superintendence of the Topographical Branch was carried on by Colonel G. C. DePrée, Surveyor General, up to the 23rd February 1886, when he was compelled by ill-health to proceed on furlough. From that date the duties have been performed by Lieutenant-Colonel H. R. Thuillier, R.E., who was then appointed to officiate as Surveyor General. The immediate superintendence of the Revenue Branch was continued by Lieutenant-Colonel Thuillier, Deputy Surveyor General, up to 11th March 1886, when Colonel J. Sconce, S.C., Deputy Surveyor General, the permanent incumbent of the post, returned from furlough and resumed charge. The direct charge of the Trigonometrical Branch has remained in the hands of Colonel C. T. Haig, R.E., Officiating Deputy Surveyor General, throughout the year.

3. The operations which have been carried out during the year under review are shown in the following tabular statement, and they are described in detail in Part II of this Report in the order in which they are given below:—

Statement of Survey Operations and Field Parties.

Name and *locale* of operations.	Page in this Report.	Executive Officers.	Designation of Survey Party.	Scale of Survey.	Administrative Superintendent.
Triangulation.					
Coast (Madras) . .	11	Mr. E. C. Ryall . . .	Secondary Triangulation.	. . .	D. S. G. Trig.
Topography.					
Andaman Islands . .	12	Major G. Strahan, R.E. Captain J. R. Hobday, S.C. Mr. G. D. Cusson.	Andaman Survey (No. 4 Topo. Branch).	4″ and 1″=1 mile for reproduction.	Ditto Topo.
Baluchistan . . .	13	Lieutenant-Colonel J.R. Wilmer, S.C.	Baluchistan Survey (No. 3 Topo. Branch).	2″ and 1″=1 mile for reproduction.	Ditto ditto.
Cutch	16	Colonel A. Pullan, S.C.	Cutch Survey . .	2″=1 mile for reduction to half scale.	Ditto ditto.
Deccan	17	Lieutenant-Colonel D. C. Andrew, S.C.	No. 11 Rev. Branch	2″=1 mile for reduction to half scale.	Ditto Rev.

Statement of Survey Operations and Field Parties—continued.

Name and *locale* of operations.	Page in this Report.	Executive Officers.	Designation of Survey Party.	Scale of Survey.	Administrative Superintendent.
Gujarát	18	Lieutenant-Colonel W. F. Badgley, S.C. Mr. J. Newland.	Gujarát Survey	2″=1 mile for reduction to half scale and 200ft. = 1 inch (city) for reproduction.	D. S.-G. Topo.
Mirzapur	19	Mr. W. H. Patterson	Mirzapur Survey (No. 5 Topo. Branch).	2″=1 mile for reduction to half scale and 16″=1 mile for reproduction.	Ditto Trig.
Mysore	21	Major J. R. McCullagh, R.E. Lieutenant H. M. Jackson, R.E.	Mysore Survey (No. 8 Topo. Branch).	4″=1 mile for reproduction.	Ditto Topo.
Rajputana	23	Lieut.-Colonel R. Beavan, S.C. Lieutenant W. H. Pollen, R.E.	Rajputana Survey (No. 1 Topo. Branch).	1″ and ½″=1 mile for reproduction.	Ditto Trig.
South Maratha	24	Major J. Hill, R.E. Lieutenant F. B. Longe, R.E.	No. 10 Rev. Branch.	2″=1 mile for reduction to half scale and 8″=1 mile, Skeleton Forest Survey.	Ditto Rev.
Forest Surveys.					
Burma	26	Mr. H. Hörst	Burma Survey (No. 3 Topo. Branch).	4″ and 2″=1 mile for reproduction.	Ditto Topo.
Cadastral Surveys.					
Akyab	28	Lieutenant-Colonel H. S. Hutchinson, S.C.	No. 7 Rev. Branch	16″=1 mile for reproduction.	Ditto Rev.
Basti	29	Lieutenant-Colonel S. H. Cowan, S.C.	No. 4 Ditto	16″=1 mile for reproduction.	Ditto ditto.
Bilásput	31	Lieutenant-Colonel E. H. Steel, S.C.	No. 2 Ditto	16″=1 mile for reproduction.	Ditto ditto.
Gorakhpur	34	Major J. E. Sandeman, S.C.	No. 5 Ditto	16″=1 mile for reproduction.	Ditto ditto.
Kámrúp	37	Mr. E. C. Barrett	No. 6 Ditto	16″=1 mile for reproduction.	Ditto ditto.
Mozufferpore	39	Lieutenant-Colonel W. Barron, S.C.	No. 8 Ditto	16″=1 mile for reproduction.	Ditto ditto.
Traverse Surveys.					
Ajmere	43	Mr. A. J. Gibson	Ajmere Detachment	16″=2 mile (skeleton plots).	Ditto ditto.
Jubbulpore and Damoh	44	Mr. G. H. Cooke	No. 9 Rev. Branch	16″=1 mile (skeleton plots).	Ditto ditto.
Punjab	46	Lieutenant-Colonel F. Coddington, S.C.	No. 1 Ditto	2″=1 mile compilation for reduction to half scale.	Ditto ditto.
Raipur	47	Lieutenant-Colonel W. H. Wilkins, S.C.	No. 3 Ditto	16″=1 mile (skeleton plots).	Ditto ditto.
Sambalpur	48	Mr. A. D'Souza Mr. P. A. G. Cowley.	Sambalpur Detachment.	16″=1 mile(skeleton plots).	Ditto ditto.
Geographical and Miscellaneous.					
Himalaya	50	Colonel H. C. B. Tanner, S.C. Captain R. A. Wahab, R.E.	Himalaya Survey	4″ and 2″=1 mile for reduction to half scale.	Ditto Trig.
Upper Burma	53	Captain J. R. Hobday, S.C.	Upper Burma Detachment.	¾″ and ½″=1 mile	Ditto Topo.
Nepal and Tibet	54	Explorers M. H. and R. N.	. . . .	. . . .	Ditto Trig.
Tidal and Levelling Operations.					
Tidal Operations	55	Major J. Hill, R.E.	Tidal and Levelling Party.	. . . .	Ditto ditto.
Spirit-levelling	57	Major A. W. Baird, R.E.			
Geodetic.					
Latitude operations and Electro-Telegraphic determinations of Longitudes.	58	Major G. Strahan, R.E. Major W. J. Heaviside, R.E. Lieutenant S. G. Burrard, R.E.	Nos. 1 and 2 Astronomical Parties.	. . . .	Ditto ditto.

TRIANGULATION.

4. It will be seen from the last statement that only one small party was employed in secondary triangulation. The operations of this party extended from Cocanada to Masulipatam on the East Coast, with the object of fixing the positions of beacons erected at suitable points, and of other permanent and conspicuous marks, natural or artificial, for the use of the Marine Survey Department.

5. The annexation of Upper Burma will ere long lay the Government under the necessity of extending the principal triangulation over the newly acquired territory, but in the present state of the country it would be premature to formulate details for so extensive a project: it will suffice to say that for such a large area a very accurate trigonometrical basis will be required for the subsequent surveys, if they are to be undertaken on a scale at all in keeping with those in India Proper.

6. The secondary series, in extension of the Eastern Frontier Series, through the Malayan peninsula down to Singapore, still remains to be executed, and would have been commenced ere this had officers and funds been available for the purpose.

SPECIAL OPERATIONS.

7. The two transit instruments having been returned from England, where they had been sent for repairs, the Latitude operations were suspended, and the Electro-telegraphic observations for the determination of differential Longitudes were resumed by the Astronomical Parties. Nine arcs have been measured between stations of the Trigonometrical Survey.

8. The Tidal observations have been duly continued in accordance with the original programme for obtaining a systematic record of the tidal phenomena on Indian coasts. Four new observatories have been established, *viz.*, at Bhávnagar, Cochin, Cocanada and Chittagong; and three have been closed, *viz.*, at Diamond Harbour, Amherst and Moulmein, where the usual period of five years' registration had been completed; Moulmein having been continued for a sixth year owing to certain peculiarities in the tides of that port.

TOPOGRAPHY.

9. During the preceding year, thirteen field parties had been employed on Topographical Surveys, exclusive of Forest Surveys: of these, two parties had completed the work assigned to them, *viz.*, the Assam and North-East Frontier Party, and the Malwa Party. Under the orders of the Government the former of these parties was broken up and the latter was diverted to Revenue operations; a third party which had been employed temporarily during that year, on topographical operations in the Shwegyin District, Lower Burma, was also withdrawn for cadastral operations in the Central Provinces, so that during the year under review the topographical surveys were reduced to ten parties, of which the Himalaya Party has as yet yielded little but triangulation and the skeleton traversing to meet the requirements of the Settlement Department in connection with the *Patwari* survey. The regular topographical operations were carried on by those parties in continuation of the work of the previous year, with the exception of the Konkan Survey, which had been completed and the party transferred to the Southern Marátha country. During the year the surveys of the Andaman Islands, of Cutch and of Mysore, have been completed.

10. It had been intended to employ the party set free from the Andaman Survey in regular survey operations in the newly acquired province of Upper Burma during the current field season, but owing to the unsettled state of the country it has been decided to postpone the commencement of these operations until more favourable conditions exist, and the party will, in the meantime, be engaged in carrying out a topographical survey of the Nicobar Islands, which is much needed.

The completion of the Mysore Survey has released a party to undertake the topographical surveys in the Madras Presidency, which have been hitherto carried on by the Madras Survey Department under the Local Government, and the transfer of which to the Imperial Survey Department has been lately decided

on. The uncompleted portions of the following districts will therefore be surveyed by this Department on the standard scale of 1 inch=1 mile, *viz.*—Ganjam, Vizagapatam, Tinnevelly, Madura, South Canara and Malabar, comprising an aggregate area of about 12,400 square miles.

The party lately employed in Cutch, as well as that recently engaged in the South Deccan, was transferred at the close of the year under report to undertake Revenue Survey work in the Central Provinces, so that at the present time the number of parties employed on topographical surveys is reduced to eight, excluding the Burma Party, the operations of which are confined to Forest Surveys.

11. The general out-turn of topography executed during the year amounts to 19,162 square miles, which is exclusive of Forest Surveys and of the standard mapping compiled by the Punjab Party from *Patwari* surveys :—

5,518	square miles surveyed on the		½-inch scale.	
2,826	„	„	1	„
10,784	„	„	2	„
28	„	„	4	„
6	„	of city survey „	26·4	„

In connection with the Baluchistan Survey, reconnaissance surveys were also executed on the ¼ inch and ⅛ inch scales, embracing an area of about 30,000 square miles.

RIVERAIN AND FOREST SURVEYS.

12. The Riverain Survey, on the scale of 4 inches=1 mile, along the Gogra River, carried on in District Fyzabad in connection with the cadastral survey of the Basti District, has been completed; and a series of maps embracing the entire low-lying tracts on both sides of the river, with the details of the village boundaries, intended to facilitate the restoration of boundaries when changes occur in the course of the river, has been prepared.

13. A forest survey on a new system has been begun in the Belgaum District, but as the work was taken in hand late in the season, a small area only has been accomplished. The maps of this survey are on the scale of 8 inches to a mile and are little more than skeleton maps, showing village and forest boundaries, together with perennial streams and made roads; they are intended to be completed by the officers of the Forest Department to the extent that may be necessary to make them serve as working plans. These Belgaum forests lie within the area under topographical survey by the South Marátha Party, so that their full topography is being surveyed simultaneously on the 2-inch scale along with the partial details on the larger scale, as required by the Forest Department.

14. The Burma Party has continued the survey of the forests in the Prome and Tharrawaddy Districts, where, in addition to the physical difficulties of the country which were met with as usual, the outbreak of disturbances by dacoits materially influenced the progress of the operations and added greatly to the anxieties and responsibilities of the surveyors. The interruptions to the work and loss of time involved by the necessity for changing the programme during the season, and the subsequent withdrawal of the party from the field a month earlier than usual, have naturally caused a diminution in the out-turn of work compared with that of the previous year.

The areas of these operations are:—

	Square miles.
Riverain	36
Forest	330

CADASTRAL SURVEYS.

15. The operations of four Cadastral Parties have been continued in the same districts in which they had previously been employed; these are, the two North-West Parties in Districts Gorakhpur and Basti; the Assam Party, in the Kámrúp District; and the Burma Party, in the Akyab District. Another old cadastral party has been transferred from the Henzada District of Burma to the Mozufferpore District of Bengal to initiate a cadastral survey there. A new cadastral party has been raised on the nucleus of the late Shwegyin Topographical Party for the cadastral survey of District Biláspur in the Central Provinces. Thus six cadastral parties have been working during the season. In the North-West Provinces, the two parties employed there have continued the preparation

of the same papers which constitute the Record of Rights and furnish the basis for a new Settlement, and, as before, have also compiled the statistical statements of crops and classes of inhabitants. The Gorakhpur Party has a total cost rate, both for survey work proper and for all extraneous work done for the Settlement, of R170-5 per square mile, which is practically the same as last year's rate, while the work done in the Survey office has actually been increased by the transfer of the preparation of the Urdu *jamabandis* from the offices of the Deputy Collectors. The Basti rate is considerably less than that of last year, but is still higher than the Gorakhpur rate, being R197-1-6 per square mile. The higher rate is fully accounted for by the small size of the fields, which gives a very much larger number per square mile to be surveyed and recorded. The Basti rate per field is considerably less than the Gorakhpur rate per field. The survey expenditure in both parties has been carefully watched, and it is still believed that any reduction in the cost of the joint operations of survey and settlement must come from the Settlement Department. The fairing of records, which in one of the districts is said to cost more than the original preparation, is again brought to notice as an item of settlement expenditure on which a considerable reduction might be effected.

16. In the Kámrúp District of Assam, the cadastral survey has been carried on under the same system as in previous seasons, and the work includes the preparation of a *khasra* (register) specially adapted for the *raiyatwari* tenure obtaining in the province. The cost rate has been reduced from R215-5 of the past season to R196-3 of the present season.

17. In the Akyab District of Burma, the operations consist of purely survey work, no register of any kind being prepared. The out-turn includes some narrow strips of country situated in different valleys, which has made the supervision of the work a matter of considerable difficulty. The rate has been reduced from R294-13 of the previous season to R244-1 during the present season.

18. In Bengal, the cadastral survey, with preparation of a record of rights, for Mozufferpore has been undertaken as an experimental survey under the Bengal Tenancy Act, the experiment having been instituted for the purpose of testing the feelings of the people of Behar, with regard both to the mapping of the holdings and to the concurrent inquiries into occupancy rights, as well as to ascertain the probable cost of such operations with the view to their being extended, if all matters should be found favourable, to other permanently settled districts of the province of Bengal. The result of the experiment as concerns the temper of the people was in every way satisfactory. The landlords offered no opposition, as had been feared they might have done through their regarding the formal recording of the rights of the tenants as a restriction of their proprietary rights. The tenants did not object to the measuring of their fields, which had been partly expected, through apprehension of an increase of rents, though it was also evident that they were still ignorant of the great advantages accruing to them from the accurate record which was being made of their holdings, and generally they were found to be passively indifferent to the operations which were being conducted. The cost of the survey has been at the total rate of R269 per square mile (or about 6 annas 9 pies per acre), made up of a rate of R140 for the operations of survey proper, and of R129, the sum of the rates for writing and compiling the records. (See tabulated statement of rates at page 64). The total rate is obtained after including with the expenditure several charges not likely to be repeated, and which have been incurred through the party having to be transported from a distant province and having to be equipped for new operations. The rate has also been obtained from an out-turn of 413 square miles, which is only about half of what a party might ordinarily be expected to accomplish in Behar after being specially organized and trained, but which could not be exceeded during the first season, when there had been no preparatory traversing, when many new men had to be taught surveying, and all had to be instructed in the particulars required to be recorded in the village papers. For next season, local establishments had been trained, and if the survey had been continued, it was confidently expected that an area of 800 square miles would have been accomplished, and that the entire operations of survey and preparation of the record of rights would have been effected for less than R200 per square mile, or below 5 annas

an acre. As regards the stoppage of the survey, it is unnecessary to offer any remarks except to express regret at the abandonment of a work calculated to be of great benefit to the public interest, to the interest of landlords, and to the interest of tenants, and to place on record that the cause of the stoppage has been the failure of the Bengal Government to obtain sanction to the levying of cesses from landowners and tenants to cover half the cost of the operations which was part of the project when the experimental survey was undertaken.

19. For the new cadastral party which has been employed in the Bilâspur district, the old establishment of the Shwegyin Party provided only for the traversing part of the work, and the larger proportion of the party required for the field surveying and writing the village papers had to be engaged in the North-West Provinces, from among the large numbers of men who make surveying a profession in many of the districts there, and thence they were taken down to Bilâspur, where local *amins* were not available. The system of preparing the village records required for a settlement concurrently with the survey, as is followed in the North-West Provinces, has been adopted for Bilâspur. This system was new to most of the members of the party, and all had to make strenuous exertions to learn, not only the system, but also to acquire a knowledge of the nature of the land tenures in Bilâspur. The result of the season's operations is highly creditable to all concerned, a total area of 763 square miles having been cadastrally surveyed, out of which the records have been written in 606 square miles. The cost rate on the latter, or completed area, is ₹169-11, which, it is confidently expected will be reduced next season.

The areas surveyed cadastrally are:—.

	Square miles.
North-West Provinces	1,603
Assam	468
Burma	661
Bengal	413
Central Provinces	763
TOTAL	3,908

TRAVERSE SURVEYS.

20. The Punjab Party has continued the same operations as last reported. Its main work is skeleton traversing to determine the co-ordinate distances of village tri-junctions for the construction of general maps on which the topographical details are inserted by transfer from the Settlement Survey village maps. The co-ordinate distances are also employed in districts coming under settlement survey, to test the accuracy of the frame-work for the village maps which is laid out by the Settlement surveyors on their own system. In several districts not yet surveyed for settlement purposes, the traversing might be utilized, with slight modifications in its design, as a basis for the construction of the village maps, but the Settlement authorities prefer to lay out a frame-work for themselves. The Survey party, besides compiling general maps from Settlement Survey materials, also tests the topography after the maps have been compiled.

21. In the Central Provinces, the system which had been tried as an experiment for two seasons in Districts Raipur and Sambalpur, of surveying the boundaries of blocks of fields, within which the *Patwaris* were intended to insert the individual fields, has been abandoned, partly because of the difficulty which was experienced in recognizing the plotted boundaries on the ground, and partly because it was found that the *Patwaris* could survey equally well with the assistance of traverse points only. In place of the "field block" survey, a simple skeleton traverse survey has been substituted, which will furnish points in suitable positions on the boundaries of small villages, and, in large villages, additional points in the interior of the village lands, so as to form complete skeleton maps on which the *Patwaris* will plot their measurements of the fields. The scheme involves the fixing of substantial mark-stones at all the traverse points. This system will be extended to 17 districts in the Central Provinces, and when fully developed will employ an extreme number of five survey parties. During the past season, two full parties and one half party have been employed in Districts

Raipur, Sambalpur, Jubbulpore, and Damoh, and a total area of 5,269 square miles has been surveyed.

22. A small detachment has been employed in District Ajmere, extending to the *jagir* and to a few minor *istimrar* villages the same system of boundary traversing for the purposes of a settlement survey of the fields as had been carried on for the *khalsa* villages during two previous seasons. All the survey work of this nature required in Ajmere-Merwara has now been completed.

The areas which have been traversed are —

	Square miles.
Punjab	3,770
Ajmere	243
Central Provinces	5,269
TOTAL	9,282

GEOGRAPHICAL RECONNAISSANCES AND EXPLORATIONS.

23. The year under review has been a memorable one as regards geographical surveys and reconnaissances. The delay in the settlement of the Russo-Afghan Boundary was turned to profit by the Survey officers attached to the British Commission, *viz.*, Major Holdich, Captains Gore and Talbot, all of the Royal Engineers. By making the most of every opportunity which presented itself, and being efficiently aided by their native staff, they have succeeded in making a reconnaissance survey of a very large portion of Afghanistan, amounting to an area of about 120,000 square miles—a result which is believed to be unique in the annals of geographical surveying. The whole of this work is based on a net-work of triangulation, mainly executed by Captain Talbot, R.E., extending from Mashhad on the west, to beyond Kabul on the east, and to Farah on the south, a fact which gives the work a value far beyond that generally appertaining to geographical surveys.

The longitudes of the triangulation depend on the value of the longitude of Mashhad telegraphically determined by Captain Gore, R.E., as described in the appendix to the Annual Report for 1884-85.

24. In addition to the legitimate work of surveying and delimiting the actual Russo-Afghan Boundary, the whole of the Province of Herat, including the hitherto unknown and exceedingly interesting Taimani and Firozkuhi country, has been mapped; almost the entire Province of Afghan-Turkistan has been surveyed or reconnoitred, including a large portion of the Hazara country lying in the neighbourhood of Bamian, while, during the return march of the Commission, all the important passes of the Hindu Kush have been surveyed and reported on.

25. In addition to this, the survey of a considerable portion of Eastern Khorasan has been executed, in continuation of which work, Captain Gore, returning to India through Persia, has surveyed the route from Herat *vid* Birjand through the Lut desert to Kirman and Bandar-Abbas.

26. The Survey Party were much indebted to Major Maitland and Captain Peacocke, R.E., of the Quartermaster General's Department, for several valuable reconnaissances.

27. The detailed report on the geographical results of the Afghan Boundary Commission will be drawn up by Major Holdich, R.E., and published as a separate volume by order of the Government.

28. The Government of India have been pleased to acknowledge the valuable services of the Survey officers attached to the Mission, and have expressed their satisfaction with the results obtained.

29. Colonel Woodthorpe, R.E., whose deputation to join the Gilgit Mission was mentioned in the last Annual Report, has thoroughly sustained his reputation as a most able and intrepid explorer, and he has brought back a mass of valuable information and surveys of the very important and hitherto little known districts of Yasin, Chitral, Hunza and Wakhan: his surveys cover an area of some 10,000 square miles, nearly all of which was hitherto only known to us by report or from the rough reconnaissances of native explorers.

30. In Upper Burma, a small detachment under Captain Hobday has been engaged since April 1886 in adding to our scant knowledge of the geography of that country as far as the movements of the troops allowed.

31. Our geographical knowledge of Nepal and Tibet has been extended by the route survey of Explorer M—H, who, having followed up the Dudhkosi River to its source, crossed the great Himalayan ridge at a pass about 24 miles west-north-west of Mount Everest and proceeded northwards to Dingri Maidan. Thence he proceeded westwards to Jongkhajong (about 90 miles due north of Khatmandu) and returned to India *viâ* Naiakot and the Naraini or Gunduk River.

32. The routes followed up by Explorer R—N have also opened up the general geography of Western and Eastern Bhutan, of which but little was known, and have furnished a good nucleus for the compilation of Sheet No. 7 of the North-East Trans-frontier Series of maps. Starting from Darjeeling, the explorer crossed the Sikkim frontier at the Pángula Pass and proceeded at first eastwards and then southwards along the Wongchhu River to Baxa in the Jalpáiguri District. He next started from Dewángiri in Assam, and proceeding northward, crossed the Himalayan ridge in latitude 28° and longitude 91¾°, and thence found his way to Odálguri *viâ* Tawáng. Further information on the foregoing routes will be found in Part II, but the detailed accounts and maps illustrative of the same cannot be got ready in time for this Report.

PUBLICATIONS.

33. The work in the various Cartographic Offices has been carried on with much activity, and a large amount of work has again been turned out. The total number of maps issued during the year amounted to 210,288 and their value to R1,66,749. Considerable progress has been made in the Lithographic Office with the publication of the series of maps illustrating the physical and material state of India, originally prepared for the Calcutta Exhibition of 1883-84. The preliminary Canal Map of India, on the scale of 1 inch=32 miles, was under preparation and ready for printing. The Contour Map on the same scale, showing the mean elevation of the different parts of the country, has been published. On the smaller scale of 1 inch=80 miles, two maps which have been published are worthy of special notice, one illustrating the distribution of the principal religions of India, which shows at a glance the habitat of the men professing the principal religions, and the other the density of population based on the census of 1881. These maps are excellent specimens of chromo-lithography, and will compare fairly well with similar work executed in other countries.

The Military and Railway Map of India, on the scale of 1 inch=32 miles, which was referred to at page 10 of the last Annual Report, has made good progress. Four sheets have been drawn on stone for printing in four colours, and seven more sheets remain to be finished. The map is being prepared for the Military authorities, and will be as complete in all military details as is compatible with the small scale.

34. The value of photo-zincography as a means of rapidly making the results of surveys available to the public, is shown by the fact that no less than 370 sheets of standard maps of the Topographical and Revenue Surveys in the Andamans, Burma, Gujarát, Káthiáwár, Konkan, Mysore and the Punjab have been photo-zincographed and published during the year: some however are reprints. Among City and Cantonment Plans, the City of Mysore, on the scale of 12 inches=1 mile, and that of Jeypore with Amer, 6 inches=1 mile, printed in two colours, may be mentioned. A large number of District Maps, on the scale of 1 inch=8 miles, intended for the illustration of Administration Reports, have been published and are available for District officers requiring them.

The work of reproducing the results of the cadastral surveys in the North-West Provinces, Burma, Assam and Bengal has steadily proceeded, and during the year 5,203 sheets have been published, partly by photo-zincography from the original sheets, and partly by zincography from tracings made in lithographic ink.

GENERAL REMARKS.

35. The large demands that have been made on the Survey Department for officers required to accompany political missions and military expeditions, and for other special work, combined with the circumstance of a larger percentage than usual being absent on medical leave, has rendered the efficient prosecution

of the regular work of the department peculiarly difficult. This has been the subject of remark in the Annual Reports for the past two years, and during the year under review, the paucity of officers has been still more seriously felt. There has been absolutely no reserve of trained officers, and the administration of the department has consequently been a task of considerable anxiety; it is necessary to record that the working machinery of the department has been limited to a dangerous extent.

36. During the year the Department has sustained the loss of the services of Lieutenant-Colonel J. Herschel, R.E., F.R.S., by his retirement on 10th March 1886, after a service of 26 years in the Survey Department, during which period he has aided largely in maintaining the scientific character of its operations. For the first few years he was employed on the Principal Triangulation, and took an important share in the measurement and reduction of the Base-lines at Bangalore and Cape Comorin: he commenced the observations for Latitude with Strange's Zenith Sectors, and also initiated the electro-telegraphic observations for Longitude in conjunction with Captain (now Major-General) W. M. Campbell, R.E., and systematised the procedure for the reduction of both. He was entrusted by the Royal Society with the charge of the observations of the eclipse of the sun on the 18th August 1868, which he sucessfully conducted, and obtained results most valuable to science; he also took part in the observations of the solar eclipse of 12th December 1871, conducted by Colonel Tennant, R.E. During his service in the Computing Office at Dehra his mathematical talent was of great value: it was to his exertions there that the department owes the method of treating the computations of polygonal figures according to the principal of minimum squares, in place of the old method, by successive approximation. Colonel Herschel has also rendered valuable assistance in the investigations connected with the reduction of the Pendulum observations, and he contributed materially to Volume V of the Account of the Great Trigonometrical Survey, which is devoted to that subject. Since November 1879, Colonel Herschel has been employed on special duty in England, in collating the data obtained from Pendulum observations in other parts of the world, with a view to combining them with the results of the Indian observations—a work involving much patient research.

37. A collection of specimens of every kind of map, and of the different processes employed in reproduction by the Survey Department, was sent to the Colonial and Indian Exhibition of 1886, as well as an elaborate model of India, based on the 32-mile map, made in plaster-of-paris by Major C. Strahan, R.E. It was the first attempt at anything of the kind. The vertical scale is 12 times the horizontal one, so that the mountains are well seen, the highest peak of the Himalayas being nearly 2 inches in height.

38. The Geographical Society of Paris have awarded a gold medal to the Explorer A-K, Pundit Kishen Sing, in recognition of his valuable services in connection with geographical explorations in Tibet during the years 1879-82. Much additional knowledge of this country had been hoped for from the Tibet Mission, to which Colonel Tanner had been attached as Survey Officer, but these expectations were unhappily not realized.

PART II.

SUMMARY OF THE OPERATIONS OF THE TRIGONOMETRICAL, TOPOGRAPHICAL AND REVENUE SURVEY PARTIES.

TRIANGULATION.

COAST—GODAVARI AND KISTNA DISTRICTS.

THE COAST SURVEY PARTY.

39. On the transfer of Mr. D'Souza, the officer who during the two previous seasons had conducted these operations, the charge of the party was entrusted to Mr. E. C. Ryall, who was directed to continue the triangulation southwards from the side, in the vicinity of the Godávari River, where it had terminated in May 1885.

Personnel.

Mr. E. C. Ryall, Officiating Deputy Superintendent, 4th grade.

Mr. R. W. Senior, Assistant Surveyor, 2nd grade.

40. The party left Calcutta on the 25th of October, but owing to the rough weather met with, they did not reach Cocanada till the 4th November. The country to the south having been reported to be under water, Mr. Ryall determined to prospect the ground for himself before commencing operations. He met "with nothing but creeks and extensive swamps, divided here and there by long, narrow strips of palmyra and cocoanut." As the swamps were not of fresh water, but due to the flood and spring tides, he saw that it would be useless to wait any longer, so he hurried back to Cocanada to entertain boats and men and to lay in supplies. The approximate work (consisting of the selection of suitable stations, their building, and the clearing of the rays between them), was sufficiently advanced by the 3rd of December to allow the commencement of observations. After a week's instruction, Mr. Senior was detached to Masulipatam with orders to work northward, while Mr. Ryall purposed triangulating southwards till a junction was effected. The old triangulation of the Madras Coast Series furnished bases for emanation of the southern section, while the northern was in continuation of that of the previous season; the object of the triangulation being, as stated in former reports, to construct beacons for the benefit of the Marine Department, and to fix their positions as well as the positions of other conspicuous objects and landmarks.

41. Owing to repeated attacks of malarious fever, Mr. Ryall was unable to contribute as much work as he had hoped. He nevertheless carried down the series for a distance of 65 miles, and, having effected a junction with Mr. Senior's work at the southern mouth of the Godávari, proceeded to Masulipatam to continue the triangulation further south, when severe illness compelled him to retire from the field. Mr. Senior, however, carried on the work of the party till the close of the season, bringing up the out-turn to 145 miles (direct distance) of triangulation, by which the positions of nine beacons and of seven other permanent and conspicuous objects were fixed.

During the recess, the records of the previous season were re-examined and finally arranged, and the usual calculations and charts illustrative of the work now reported on were prepared.

TOPOGRAPHY.

ANDAMAN SURVEY.

42. During the year under review, the survey of the Andaman Islands, with the exception of a large part of Little Andaman, which was impracticable, has been successfully completed. The operations consist of a general survey of the group of islands on the scale of $\frac{1}{2}$ inch = 1 mile, with special portions round the Settlement of Port Blair on the 4-inch scale.

Personnel.

Captain J. R. Hobday, S.C., Officiating Deputy Superintendent, 4th grade, in charge up to 20th March 1886.
Major G. Strahan, R.E., Deputy Superintendent, 1st grade, in charge during the recess season.
Mr. G. D. Cusson, Assistant Surveyor, 1st grade, in charge from 20th March to 17th May 1886.
„ J. Keating, Assistant Surveyor, 2nd grade.
„ D. Campbell Assistant Surveyor, 2nd grade.

Sub-surveyors.

Har Lal Singh, Faida Ali and Ali Nawaz Khan.

The party under Captain Hobday left its recess quarters at Mussooree on 31st October 1885, and proceeding to Calcutta, embarked there for Port Blair, which was reached on 24th November. The field operations were concluded on 23rd April 1886.

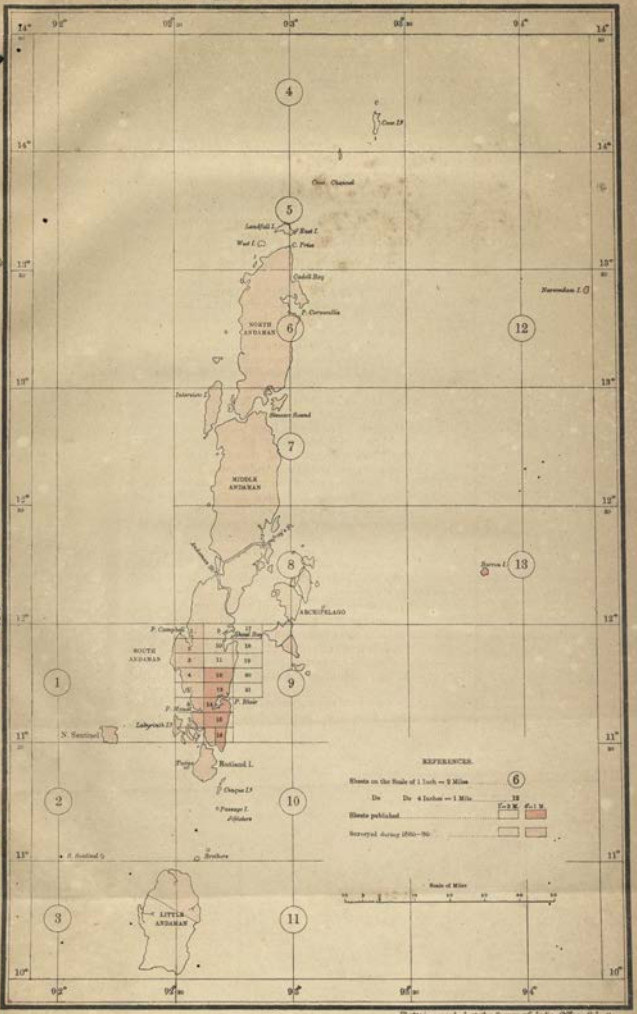
43. In March, the Military authorities made an urgent demand for Captain Hobday's services for survey operations in Upper Burma, and as the field work in the Andamans was then nearly finished, he was transferred, making over charge of the party to Mr. Cusson, the senior Surveyor, on 20th March. Before leaving, Captain Hobday drew up instructions for Mr. Cusson's guidance for completion of the field operations which were carried out in an efficient manner.

44. The triangulation, which was executed by Captain Hobday, covers an area of 955 square miles and was extended over the whole of the North Andaman and the outlying islands, and as friendly relations had been established with the inhabitants on the north coast of Little Andaman, this island also was connected in the following manner. The ray between the stations on the West Sister and Passage Islands was used as a base from which additional stations were thrown out on both the Brother Islands, and therefrom an intersected point was fixed on the north-west corner of the Little Andaman. This point was used as an origin and 24 miles of coast line, and a few creeks were surveyed, embracing an area of 68 square miles. The island afforded no facilities for extending the triangulation further, as it is flat and covered with dense jungle, and Mr. Cusson reports that "a theodolite traverse could not be attempted without previously coming to a good understanding with the natives along the western and southern shores, as their disposition to strangers was known to be hostile, and that even on the northern coast, chain measurements could not be made owing to the excitable nature of the people and their eagerness to lay hands on all the iron they saw with the party."

45. The detail survey comprised an area of 28 square miles on the 4-inch scale and 1,464 square miles on the $\frac{1}{2}$-inch scale. The nature of the country surveyed on the latter scale is thus described "numerous hilly islands, difficult of approach, covered with dense forest and intersected by numberless creeks, with frequent and extensive mangrove swamps, peopled by a few wandering savages and no supplies procurable." Much of the topography, therefore, is little more than reconnaissance.

46. The difficulties and hardships attending the survey of these islands were mentioned at page 14 of the General Report for last year, and they were met with to an equal degree during the season under review. Much credit is due to Captain Hobday and his assistants for the manner in which they have accomplished this arduous piece of work, and this has been heartily acknowledged by the Superintendent of Port Blair and the Nicobars, who has already brought to the notice of the Government of India the excellent work done by the party. The success of the operations was, however, largely due to the assistance so freely given to the Survey officers by the local authorities. Owing to the loss of the steamer *Reclaimer*, which was wrecked during the previous year, the Survey party was dependent on the local steamers, and during the greater part of the past season, the *Nancowry*, under the command of Mr. Holland, was placed at Captain Hobday's disposal. Convict labour was also provided for clearing hill-tops and making paths where required through forests,

INDEX TO THE SHEETS OF THE ANDAMAN TOPOGRAPHICAL SURVEY.



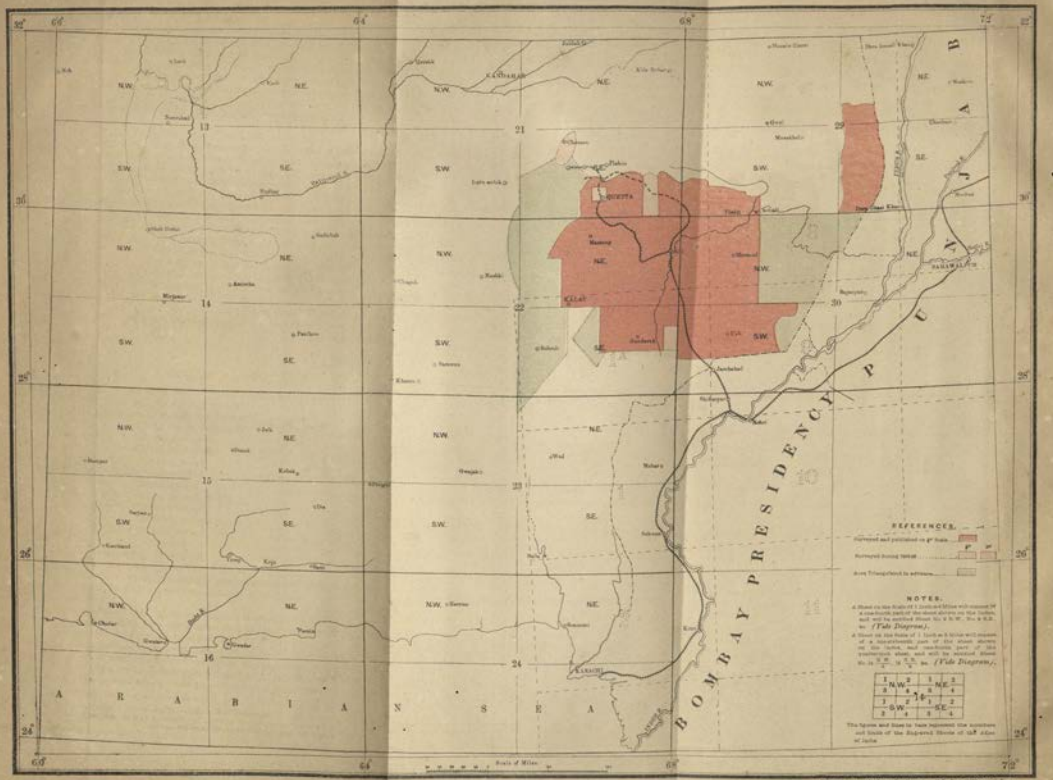
Photozincographed at the Survey of India Offices Calcutta.

Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India, Survey of India Office, Calcutta, December*

1886.

INDEX TO THE SHEETS OF THE BALUCHISTAN SURVEY, NORTH WESTERN TRANS-FRONTIER.

On the Scales of 1 Inch = 4 Miles and 2 Miles.



Published under the direction of Lieut. Colonel H. H. Thuillier, R.E., Officiating Surveyor General of India,
Survey of India Office, Calcutta, January 1887.

Photozincographed at the Survey of India Office, Calcutta.

and the men worked excellently. Captain Hobday expresses his deep sense of the valuable help he has at all times received from Colonel Cadell, V.C., the Superintendent, and from the Marine and Settlement Officers.

47. The only accident which happened during the season was the capsizing of a boat containing two constables and six convicts in the surf off North Sentinel Island. It is reported by Colonel Cadell that "Mr. Holland and Captain Hobday, on seeing the accident, at once put off in boats from the *Nancowry*, and at great personal risk saved all but one Sikh constable, who was drowned."

48. During the recess season the fair maps of the following sheets have been drawn and submitted :—

Sheets Nos. 6, 7 and 16 on the 4-inch scale, and Nos. 1, 3, 5, 6, 7, 9, 10 and 11 on the $\frac{1}{2}$-inch scale. These complete the maps of the Survey.

A chart of the triangulation in 2 sheets has also been prepared. The General Report on the triangulation of the whole of the Islands has been drawn up, and all the records connected with the work of the Andaman Party have been completed and submitted to head-quarters.

49. During the current season, this party will be employed in the survey of the Nicobar Islands. The scales of survey will be the same as those employed on the Andamans. Owing to the distances between the main islands, and, with the exception of Great Nicobar, their small elevation, it is improbable that they can be connected by triangulation; independent surveys will, therefore, be necessary of Great Nicobar, of Car-Nicobar and of Camorta and its adjacent islands, in each of which group it will be necessary to observe for latitude and to measure a base-line and azimuth, and if time and opportunity permit, to determine the difference of longitude between one or more of them and Port Blair by chronometers. The area of the islands is comparatively small, not exceeding probably 600 or 700 square miles, so that it is hoped that the work required may be accomplished in one season.*

BALUCHISTAN SURVEY.

50. The operations of this party during the past season were almost entirely of a special nature, to meet the requirements of the Military Department, and consisted of :—

Personnel.

Lieutenant-Colonel J. R. Wilmer, S.C., Officiating Deputy Superintendent, 3rd grade.
Mr. M. J. Ogle, Surveyor, 3rd grade.
„ T. E. M. Claudius, Surveyor, 4th grade.
„ E. A. Wainwright, Assistant Surveyor, 1st grade.
Mr. W. C. G. Barckley, Assistant Surveyor, 1st grade.
Mr. A. Kitchen, Assistant Surveyor, 1st grade.
Mr. E. Graham, Assistant Surveyor, 1st grade.

Sub-surveyors.

Mr. F. Rozario, from 1st March, Ahmad Ali, Abdul Rasul, Hussain Bux, Sheikh Mohidin, Kadar Sharif, Abdul Rahman, and four soldier surveyors.

(i) A survey on the 2 inches = 1 mile scale of the Khwája-Amrán Mountains, a range lying some 50 miles north-west of Quetta, on the road to Kandahar.

(ii) A survey on the 2-inch scale of the country surrounding Quetta.

(iii) An exploration of the routes between Registan and the Baluchistan frontier.

51. The remaining operations comprised a small area of topographical survey on the $\frac{1}{2}$-inch scale, to complete two sheets in which gaps had been unavoidably left; and the extension of triangulation in advance for future detail operations on the regular scale of survey.

52. On the 15th October a small detachment under Mr. Claudius left recess quarters for Quetta, to commence the preliminary work of triangulation for the Khwája-Amrán survey; operations were commenced on the 17th November, and by the 22nd December the triangulation was completed. The intense cold and inclement weather which then set in, rendered further out-door work impracticable, the range under survey having an average height at its summit of about 8,300 feet above the sea. The detachment was thus driven into winter quarters,

* Captain Hobday reports that all the assistants have afforded him entire satisfaction; and Major Strahan adds that, during the recess season, he had reason to be satisfied with their diligence and acquirements, especially in the case of Mr. Keating, who rendered excellent service.

which were fortunately available for their protection in the fort of Gulistan, and here the members were occupied in computing the results of their observations until joined by the remainder of the party at the end of January.

53. The main body of the party arrived at Quetta on the 27th December, after a trying march through the Bolan Pass - the railway then not being open for regular traffic - but owing to the severe weather, with constant snow-storms, it was forced to remain there under canvas until 22nd January, when a break in the weather occurred. It then joined the detachment at Gulistan. The weather, however, continued unfavourable until the middle of February, when some Sub-surveyors were sent out to survey the low-lying country at the foot of the Khwája-Amrán Hills. Very little survey work was accomplished, however, during February, and it may be said that the detail survey was not fairly begun until the 1st March. This survey, which included the determination of contours by the water-level along the sides of the hills at vertical intervals of 500 feet, was completed by the end of May. The portion of the range surveyed was from the Ghwája Pass on the south to the Bogra Pass on the north, including the posts of Kila Abdulla and Gulistan, in which the ground is described as very rocky, steep and intricate.

54. On the completion of the Khwája-Amrán survey the whole strength of the party was transferred to Quetta to take up the 2-inch survey required in that neighbourhood for which the triangulation had meanwhile been done and computed. Portions of the very high hills, some of them rising to 11,000 feet above sea-level, not being required in such full detail were not re-surveyed, but have been inserted in the fair map by enlargement from previous surveys.

55. The country surveyed on the $\frac{1}{2}$-inch scale, included a portion of the Harnai Valley and the hilly and barren country south of it; also a portion of flat open ground in Kachi to complete a gap in Sheet 22 $\frac{S.E.}{2}$. The survey was executed by Mr. A. Kitchen in a very creditable manner.

56. The triangulation in advance of the detail operations of the season was entrusted to Mr. Claudius, who carried the operations southwards from Gulistan generally along the meridian of 66°, over the southern portion of Peshin, the whole of the fertile valley of Shorawak and the hilly tract of Shorarud. This piece of triangulation is the more valuable as it has connected the Kandahar, Kalát and South-West Baluchistan Series, and furnishes good bases for further extension westwards. Mr. Claudius has written an interesting description of the country he traversed which will be printed separately.

57. The out-turn of work during the season comprises the triangulation and topography of an area of 620 square miles on the 2-inch scale, the survey of which was close and searching, the average number of plane-table fixings being 24 per square mile; the topography of 514 square miles on the $\frac{1}{2}$-inch scale; and 4,350 square miles of triangulation in advance for future topographical work on the $\frac{1}{2}$-inch scale. These operations were not concluded till the end of June when the party returned to recess quarters, having had a long and trying field season in which extremes of both heat and cold were experienced. The results of their labours are creditable to all concerned.

58. The four native soldiers, who had been attached to parties of the Survey Department in the previous year for instruction in surveying, were allowed to remain another season for a further course: they have all been employed in the Baluchistan Party this year and rendered excellent service in it. They took a fair share in the field operations, each having surveyed independently on the 2-inch scale an area of from 40 to 50 square miles which was well tested and found to be very satisfactory. Their work was a very useful addition to the out-turn of the party, and Colonel Wilmer reports that they have all proved themselves to be able and accurate plane-tablers. They are now thoroughly trained, and have been sent back to military duty and three other soldiers have replaced them for instruction.

59. The cost of these surveys is Baluchistan is high, but this is in a great measure accounted for by the exceptional expenditure that has to be incurred for protective escorts to the surveyors. Each detachment this year, whether under an European assistant or a Sub-surveyor, had to be protected by a tribal guard of 11 men, the monthly cost of each guard amounting to R217; this proved a very heavy item in the cost. The Agent to the Governor General at first suggested that the party should be accompanied by troops from the garrison

at Quetta as well as by tribal guards, but the Political Agent for Peshin considered that the presence of troops was unnecessary, which proved to be the case, as, with the exception of one or two petty annoyances, everything went well, and the party left the country without any complaints having been made on either side.

60. In addition to the regular operations of the party, explorations were made, on the requisition of the Quartermaster General, of the routes leading from Registan to the Quetta and Baluchistan frontier. Two Sub-surveyors, Ahmad Ali and Sheikh Mohidin, were detailed for this duty; they were each accompanied by a soldier student under training, and were placed under the orders of the Agent to the Governor General for Baluchistan, by whom arrangements were made for their protection and safety. Ahmad Ali, starting from Nushki, succeeded in making a reconnaissance survey with the plane-table of nearly 20,000 square miles, three-fourths of which was on the $\frac{1}{4}$-inch scale and the remainder on the $\frac{1}{8}$-inch scale. His exploration extended up to the Persian frontier, embracing country well to the north and south of the route followed by the Boundary Commission in 1884, including 360 miles of the course of the Helmund River with its numerous villages on both banks. He has submitted with his maps a very copious report of the piece of country surveyed, which, however, having been written in the Persian character, will take some time in being translated and reduced to suitable form. The results of the expedition are in every way very creditable to Ahmad Ali. The country explored by Sheikh Mohidin is that portion of Registan immediately west of the Khwája Amrán range. His plane-tabling covers an area of about 10,000 square miles, on $\frac{1}{8}$-inch scale, chiefly desert, through which all the important routes have been laid down.

61. Owing to the field operations of the party having been prolonged to so late a date, the recess season was limited to a period of three months only; it was impossible therefore in the time to complete all the fair maps of the ground that had been surveyed. They were taken up in the order of urgency, and the following have been completed and submitted for reproduction:—Sheets 22 $\frac{SW}{2}$ and 21 $\frac{SE}{4}$ of the general survey on the $\frac{1}{2}$-inch scale; the sheets of the Quetta 2-inch survey, which have been designed in two large sections, not of the standard size or pattern, as this arrangement would have involved a larger number of sheets, but well suited to exhibit the country operated in, either in separate sections or by joining them in one general map. The drawing of the sheets of the Khwája Amrán Survey was proceeded with as far as possible, and arrangements have been made to continue this work during the current field season without detriment to the progress of operations. Colonel Wilmer has also furnished tracings from the field sections of both these surveys for the use of Railway and Military Engineers to meet urgent requirements, and this has, to some extent, interfered with the drawing of the compiled fair maps. The computations of the triangulation have been completed and progress made with the General Degree Reports.

62. During the current field season it is intended to triangulate the portions remaining in Sheets 22 $\frac{SE}{1}$ and $\frac{SE}{3}$, the whole of 22 $\frac{SE}{4}$, 23 $\frac{NE}{1}$, $\frac{NE}{3}$ and the portions of 23 $\frac{NE}{2}$ and $\frac{NE}{4}$ which fall in Baluchistan. Detail survey on the $\frac{1}{8}$-inch scale will be carried on in the southern half of Sheet 29 $\frac{SW}{4}$, the whole of Sheet 30 $\frac{NW}{2}$ and the portions of sheets 30 $\frac{NE}{1}$, $\frac{NW}{4}$ and $\frac{SW}{2}$ comprising Baluchistan territory.

63. The recess office of the party was inspected on the 23rd September at Mussooree by the Deputy Surveyor General in charge of the Revenue Branch, who reports that the field sections are effective representations of a difficult country, and show the several surveys to have been executed with very great care. Colonel Wilmer had amply tested the accuracy of the work by numerous inspections during the progress of the surveys. The fair maps were being drawn in the office with much artistic skill.*

* Colonel Wilmer reports as follows:—"Mr. Ogle worked well throughout; Mr. Claudius is a most willing and able assistant; he rendered valuable aid in every way, and his services are brought to special notice. Mr. Wainwright is a good plane-tabler and draftsman, and his work was executed neatly and correctly. Mr. Barckley is a hardy, hard-working assistant, energetic and very willing, and turned out a good amount of work. Mr. Kitchen is hard-working, always cheerful and ready, and a very good draftsman; his name is also brought forward for favourable notice. Mr. Graham is very energetic, hard-working and a good plane-tabler. All the Sub-surveyors worked well and steadily throughout the season, especially Ahmad Ali Khan, Abdul Rasul, Hussain Bux and Sheikh Mohidin." Ahmad Ali Khan is particularly mentioned for his excellent out-turn of reconnaissance survey and perseverance under difficulties.

CUTCH SURVEY.

64. This party left recess quarters at Poona on the 22nd November 1885, to resume field work in Cutch. The field operations were continued till 31st March 1886, and they comprised the completion of the topographical survey of Cutch with its adjacent "Ran," and of the peninsula of Nagar Párkar, as well as of small portions of North Gujarát falling within the marginal sheets of the Cutch Survey. A small piece of minor triangulation was also executed, covering an area of about 250 square miles, in order to connect the triangulation of the season of 1883-84 with that of 1884-85.

Personnel.

Lieutenant-Colonel A. Pullan, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. C. Tapsell, Surveyor, 4th grade.
„ W. A. Fielding, Assistant Surveyor, 1st grade, retired on 1st April 1886.
„ G. T. Hall, Assistant Surveyor, 1st grade.
„ H. A. Charrier, Assistant Surveyor, 3rd grade.

Sub-surveyors.

N. D. Patwardhan, | G. R. Bhopatkar, and 9 others.

65. The out-turn of area topographically surveyed is 3,805 square miles, 1,500 of which is cultivable land, the remainder Ran and grass waste: it was all surveyed on the 2-inch scale for reduction to and publication on the 1-inch scale: 146 linear miles of traverses were run to demarcate *taluka* boundaries in North Gujarát. The accuracy of the detail survey was tested by 356 linear miles of traverses, and in some parts by *in situ* examinations and it was found to be good.

66. Colonel Pullan reports that the country surveyed this season was generally bare, sterile and devoid of interest, both in Cutch and in the opposite mainland of Gujarát, between which stretches the Great Ran, white with salt incrustations. Here and there, however, well cultivated spots occur, notably the oasis of Antarnes, a rich and well-watered village in the middle of the Ran. The little peninsula of Nagar Párkar is, it is added, too stony to be productive.

67. A general description of the country—the topographical survey of which has just been completed—would be superfluous here, as the *Bombay Gazetteer* lately published contains a full and well-written account of Cutch, and little that is new can now be said of prosperous, peaceful "Suryashtra." A few notes, however, on the portion surveyed this year will be found in the appendix, page i.

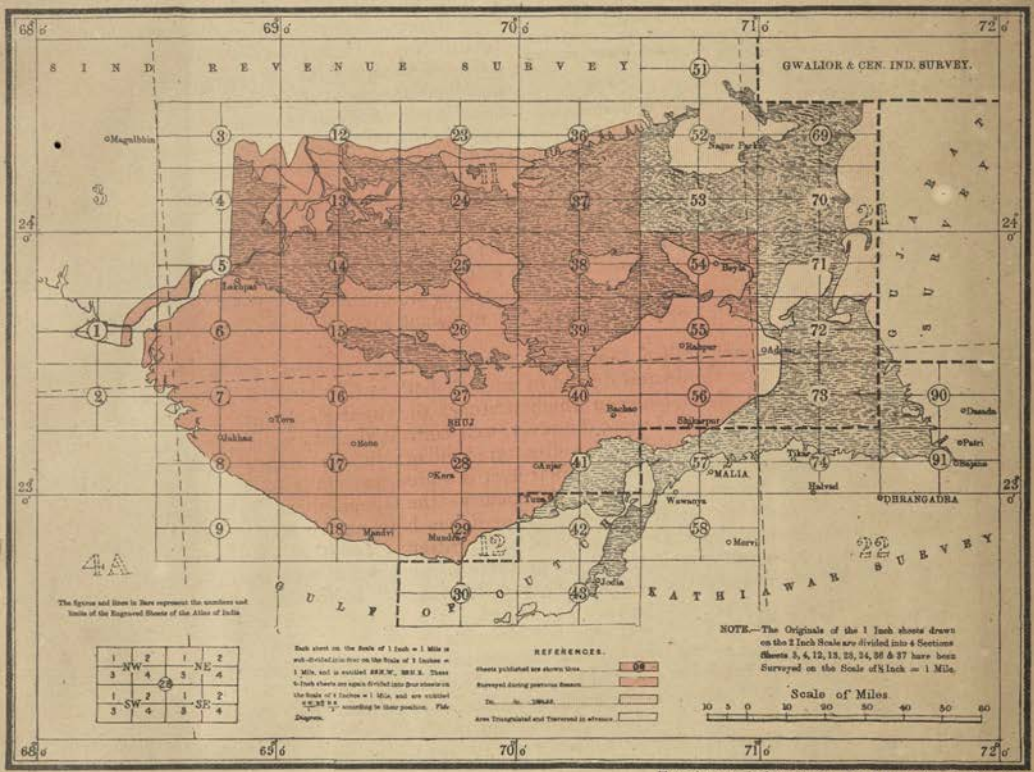
68. During the recess the fair drawing has been completed of sheets 52 and 53 which were surveyed during season 1884-85, and of sheets 69, 70, 71, 72, and 73 of this season's work; the general reports on Degree Sheets IV, V, VI, VII and VIII have been prepared and all records completed. Thus the survey of the Province of Cutch has been brought to a successful conclusion.

69. Colonel Pullan acknowledges the cordial co-operation and assistance he has received in all matters connected with the survey, from Colonels Reeves, Goodfellow and Phillips, and Diwan Bahadur Manibai Jasbai; also from Duffadar Kali Khan of His Highness the Rao's Police, who accompanied him during the whole of the operations. He also brings to notice the valuable help he received during last season from Mr. Kesheb Lall Mozumdar, Thanadar of Sántalpur.

70. This party has now been re-organized and transferred to the Revenue Branch for traverse operations in the Central Provinces, and during the field season of 1886-87 will be employed in the Districts of Saugor and Narsinghpur under the superintendence of Mr. E. J. Jackson, Deputy Superintendent, 4th grade *

* Colonel Pullan reports that Messrs. Tapsell, Fielding and Hall did a very satisfactory season's work, and he highly commends Mr. Fielding's capacities; that Mr. Charrier executed a very creditable out-turn, and shows a considerable aptitude for hill sketching and drawing. The Sub-surveyors all worked well, and the following are specially mentioned:—G. R. Bhopatkar, Keshu V. Kolekar and Shiv Ram Khandoji.

INDEX TO THE SHEETS OF THE CUTCH TOPOGRAPHICAL SURVEY.


SIND REVENUE SURVEY
GWALIOR & CEN. IND. SURVEY.
KATHIAWAR SURVEY
RANN OF CUTCH
GULF OF CUTCH
RHUJ
MALIA
DHRANGADRA
Magalbhin
Nagar Parkar
Bhuj
Anjar
Mandvi
Mundra
Jodia
Wawanya
Halvad
Dasada
Patri
Dhajdia
Sanosra
Bachau
Shikarpur
Kotra
Tera
Mota
Lakhpat
Okhaha
Marvi
Tikar
Adesar
Rapper
Boyla
Sujawas
Gujarat
Scale of Miles
10 5 0 10 20 30 40 50 60
NOTE.—The Originals of the 1 Inch sheets drawn on the 2 Inch Scale are divided into 4 Sections (Sheets 3, 4, 12, 13, 25, 24, 36 & 37 have been Surveyed on the Scale of ½ Inch = 1 Mile.
REFERENCES.
Sheets published are shown thus
Surveyed during previous season
Do. do. 1884-85
Area Triangulated and Traversed in advance
The figures and lines in Red represent the numbers and limits of the Engraved Sheets of the Atlas of India
Each sheet on the Scale of 1 Inch = 1 Mile is sub-divided into four on the Scale of 2 Inches = 1 Mile, and is entitled NE.N.W., NW.S. These 4-Inch sheets are again divided into four sheets on the Scale of ½ Inches = 1 Mile, and are entitled N.E.NE.N.E. according to their position. Vide Diagram.
NW NE SW SE

Photozincographed at the Survey of India Offices, Calcutta.

REFERENCES.

New Numbers on Index	Old Numbers on Sheets	New Numbers on Index	Old Numbers on Sheets	New Numbers on Index	Old Numbers on Sheets	New Numbers on Index	Old Numbers on Sheets	New Numbers on Index	Old Numbers on Sheets
3	3	13	11	25	19	39	27	56	35
4	4	14	12	26	20	40	28	69	36
5	5	15	13	27	21	41	29	70	37
6	6	16	14	28	22	51	30	71	38
7	7	17	15	29	23	52	31	72	39
8	8	18	16	36	24	53	32	73	40
9	9	23	17	37	25	54	33		
12	10	24	18	38	26	55	34		

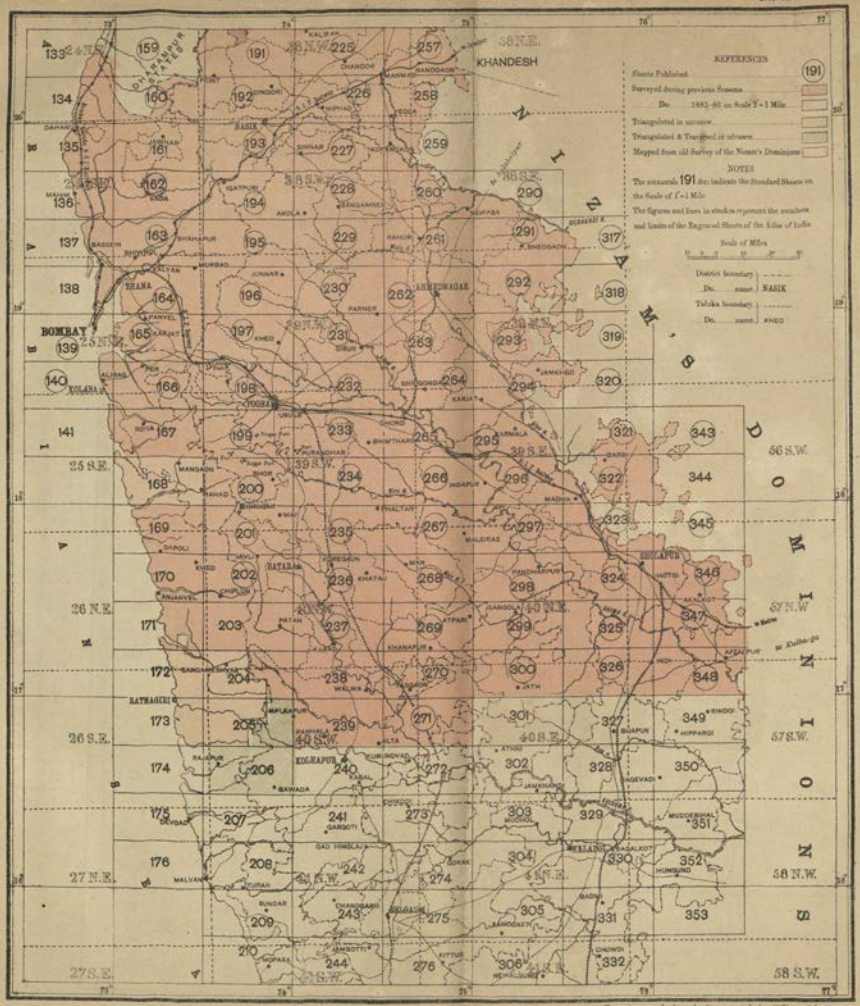
Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India, Survey of India Offices, Calcutta, December*

1886.

BOMBAY SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE DECCAN AND KONKAN.

No. 11 PARTY.



REFERENCES

New Numbers on Index	Old Numbers on Sheets	New Numbers on Index	Old Numbers on Sheets
191	4	297	49
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133	4*	245	50*
225	5	203	51
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226	9	246	56
258	10	203	57
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Published under the direction of Lieut. Colonel H. H. Thuillier, R.E., Officiating Surveyor General of India,

Survey of India Offices, Calcutta, November 1886.

DECCAN SURVEY.

(No. 11 Party, Revenue Branch.)

71. This party left its recess quarters at Poona during the first week in November 1885, in two sections, the first or smaller section proceeding to undertake the topographical survey of Sheet 168, which, comprises parts of the Kolába District and Janjira States, and was detached from the rest of the work, while the main body proceeded to the Ratnagiri District for the topographical survey of Sheets 172, 173, 204 and 205. The detachment in the Kolába District joined the main body when the survey of Sheet 168 was completed; and the party remained in the field until 20th of May 1886. Sheets 172, 173 and 204 have been finished, but three plane-table sections of Sheet 205 had to be left untouched. The separate areas of the several districts and States which have been included in the topographical survey, which as usual is on the 2-inch scale, are shown in the following statement, which gives also the total area, *viz*:—

Personnel.

Lieutenant-Colonel D. C. Andrew, S. C., Deputy Superintendent, 2nd grade, in charge.
Mr. J. T. U. Coxen, Surveyor, 4th grade, up to 31st October 1885.
„ C. Tapsell, Officiating Surveyor, 4th grade, up to 31st October 1885.
„ J. Hickie, Assistant Surveyor, 1st grade.
„ P. White, ditto do.
„ C. George, ditto 2nd grade, from 1st November 1885.
„ A. George, Assistant Surveyor, 2nd grade.
23 Sub-surveyors and others.

	Square miles.
Kolába District	278·82
Habsan State (Kolába Agency)	215·61
Ratnagiri District	1129·21
Sátára District	2·56
Vishhálgad State (Kolhápur and South Marátha Agency)	49·47
TOTAL	1675·67

72. Besides the topography, the traversing of Sheets 173, 205 and part of 172 had to be done. Sheet 206 has been triangulated in advance; but no further advance work was done on account of the intended withdrawal of the party for survey work elsewhere.

73. The topographical survey has as usual been as carefully and minutely carried out as the scale would admit, and the different kinds of lands, that is, whether cultivated or grazing land, or land covered with jungle, have been shown as far as has been practicable without impairing the clearness of the maps. The village boundaries have, as usual, all been surveyed and afterwards compared with the Bombay Revenue Survey maps. As regards forest boundaries, those in Sheet 168 have been surveyed in accordance with maps furnished by the Forest Settlement Officer of the Kolába District; but in Sheets 172, 173, 204, the forests of the Ratnagiri District not having yet been finally settled or demarcated, their boundaries have been taken up only according to what could be learnt locally concerning the preliminary demarcation. The accuracy of the topography of the field sections has been tested by *in situ* examinations at 168 stations, and by 14 linear miles of check surveys.

74. The sections on the 2-inch scale of Sheets 168, 172, 173 and 204 have been drawn and sent to Calcutta to be reduced and published in standard sized sheets on the 1-inch scale. They are also suitable for publication on the original scale of survey if required. The 2-inch sections of Sheet 205 cannot be sent in as the survey is unfinished, but they will be completed next year after the remaining portions have been surveyed, as is intended, by the South Marátha Party. The sheets of the large scale survey, 80 inches to a mile, of the town of Pandharpur have been completed and made over, at the request of the Municipal Commissioners of the town, to the Bombay Government Photozincographic Office at Poona.

75. Under orders of the Government of India, conveyed in Revenue and Agricultural Department letter No. 28-25—1, dated 11th January 1886, this party has been withdrawn from the Bombay Presidency and transferred to the Central Provinces to carry on a traverse survey there in aid of a settlement survey. It has been employed in the Bombay Presidency since October 1872 and during the fourteen seasons of its employment there under several officers, has surveyed

topographically a total area of 24,867 square miles. On its withdrawal now, it leaves undone (according to a revised programme sanctioned by the Government of India in Revenue and Agricultural Department letter No. $\frac{122}{129}$ B. S., dated 18th September 1884, which assigned to it the part of the Bombay Presidency as far south as the parallel of 16° N. Latitude), a remaining area of about 11,953 square miles of which the survey has not as yet been provided for by allotment to any other party.

76. A few descriptive notes of the part of the Ratnagiri District, which has been surveyed, furnished by Colonel Andrew, are included in the appendix, page i.*

GUJARAT SURVEY.

77. Colonel Badgley was in charge of this party at the commencement of the field season, but on the 21st February he was transferred to the charge of the Photographic and Lithographic Offices at Calcutta, in place of Colonel Waterhouse, who was proceeding on furlough The charge of the Gujarát Party then devolved on Mr. Newland, the senior Surveyor, owing to the paucity of officers in the Senior Division, and it was found impossible to appoint another officer till the end of the recess season. Mr. Newland, however, carried on the work and completed the programme for the year in a very creditable manner.

Personnel.

Lieutenant-Colonel W. F. Badgley, S.C., Deputy Superintendent, 3rd grade, in charge, to 21st February.
Mr. J. Newland, Surveyor, 4th grade, in charge, from 21st February.
Mr. G. A. Knight, Asst. Surveyor, 1st grade.
„ S. F. Norman, „ „ 2nd „
„ C. Norman, „ „ 2nd „
„ P. J. Serrao, „ „ 3rd „
And 26 Sub-surveyors.

78. A small detachment left Poona on the 15th October to undertake the preliminary traverse work for the survey of the city of Baroda on the scale of 200 feet=1 inch, which was commenced this season. The bulk of the party left recess quarters for the field by the 15th November, proceeding to their respective ground of operations in Northern Gujarát, in the Panch Mahals, and in Baroda.

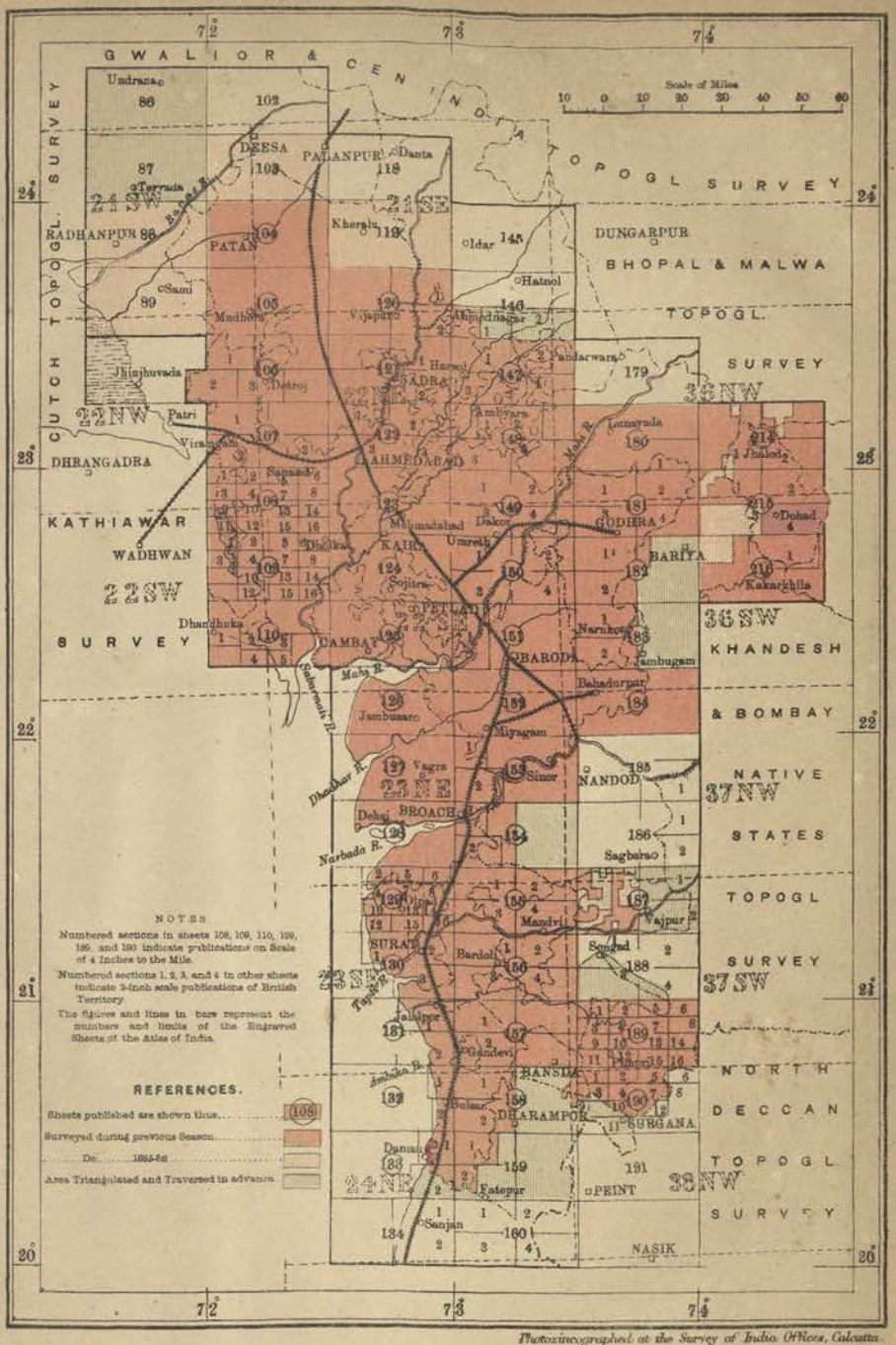
79. The original programme for the field season did not include triangulation, as it was thought that the area which had accrued from previous years was sufficient; but owing to the rapidity with which the topographical work progressed in the open plains of Northern Gujarát, it was found expedient to triangulate Sheets 87 and 188. Thus during the season an additional area of 749 square miles was triangulated: also 422 linear miles were traversed with the theodolite, viz., 78 miles in Baroda city, 118 miles to supplement triangulation, and 226 miles of the Baroda State boundary.

80. In the Baroda city, 27 linear miles of spirit-levels were run, fixing 63 bench-marks, and based on Great Trigonometrical Survey series of levels of former years. The detail survey of the city, covering an area of 6¼ square miles, was finished by the 31st March. A small party was detached in March to accompany a special Boundary Commission deputed to settle the boundary between the Gaekwar's territory and the Dangs States, as well as the boundaries of a few villages along the Baroda frontier, which had remained under dispute for many years. A small area of 17 square miles and 11 linear miles of boundaries were surveyed on the 1-inch scale, which occupied the detachment about three months. Colonel Bullock, the Boundary Commissioner, in his No. 138, dated 13th September 1886, to the Bombay Government, speaks very highly of the assistance he received from Mr. G. A. Knight, Assistant Surveyor, who accompanied him.

81. Notwithstanding the extra work as detailed above, which was thrown on the party this year, the unusually large area of 2,524 square miles was topographically surveyed on the 2-inch scale for the standard sheets of Gujarát. This large out-turn is due in a great measure to the easy nature of a large portion of the country, Sheets 88, 89, 103, and the greater part of Sheet 119, consisting merely of open plains with few topographical features. In Sheets 214, 215 and 216, however, the country was more rugged and was also densely wooded, consequently the progress of the surveyors was there much slower. Again, in Sheet 187 still greater hindrances were met with and a meagre out-turn obtained, owing to the difficult nature of the country, its extreme unhealthiness at all seasons of the year and to the dearth of water and inhabitants—three of the worst enemies a

* Colonel Andrew gives a very satisfactory report of the good services of Mr. J. Hickie and Mr. C. George. He mentions with great regret the death of Sub-surveyor Ramji Lall, a very good traverse surveyor and an exceptionally honest, hard-working man.

INDEX TO THE SHEETS OF THE GUJARAT SURVEY



NOTES

Numbered sections in sheets 108, 109, 110, 129, 130, and 130 indicate publications on Scale of 4 Inches to the Mile.

Numbered sections 1, 2, 3, and 4 in other sheets indicate 2-inch scale publications of British Territory.

The figures and lines in bare represent the numbers and limits of the Engraved Sheets of the Atlas of India.

REFERENCES.

Sheets published are shown thus..... 108

Surveyed during previous Season.....

Do. 1885-86.....

Area Triangulated and Traversed in advance.....

Photozincographed at the Survey of India Offices, Calcutta.

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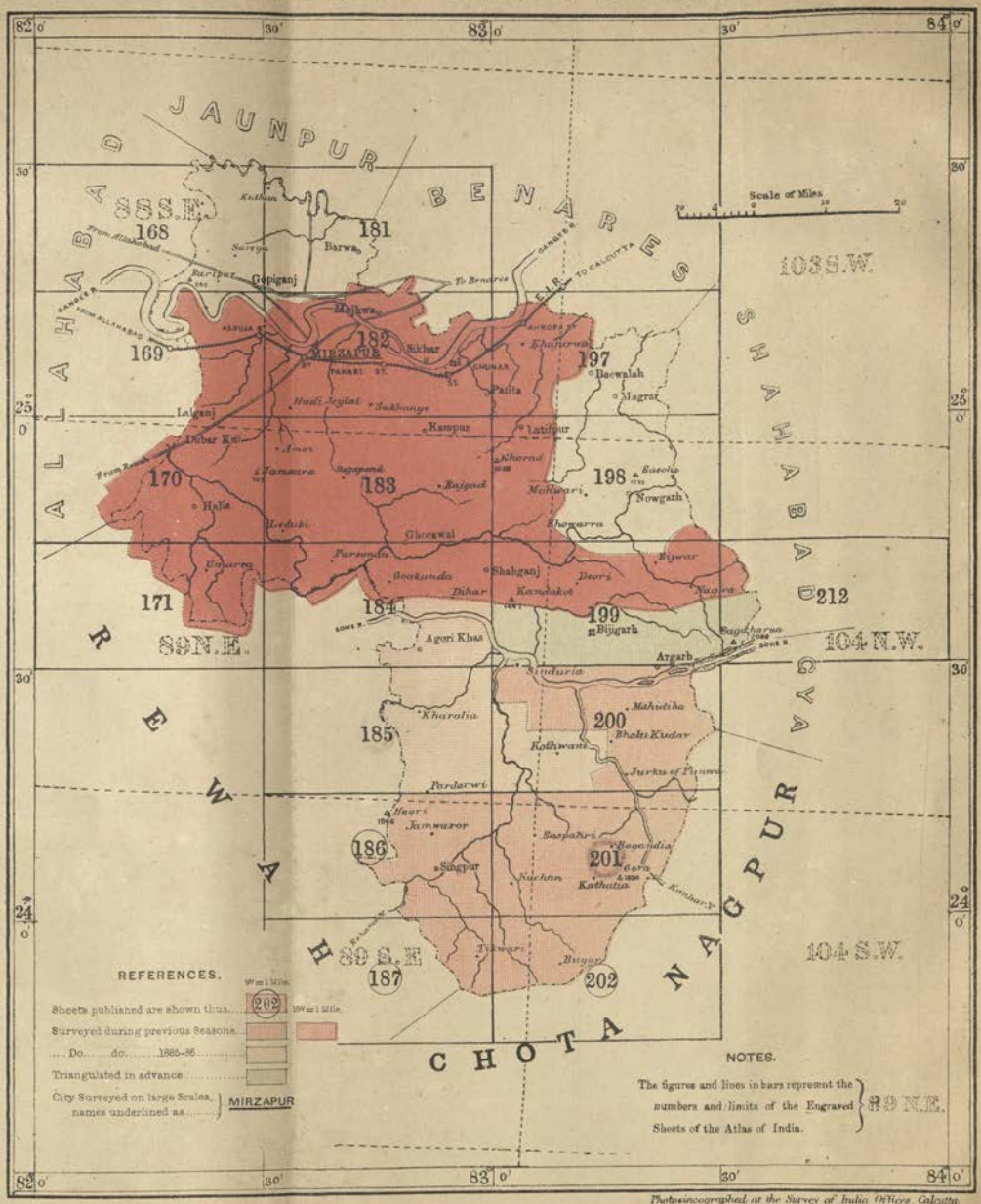
76	104	3	118	10	125	17	132	27	149	34	156	41	181	48	188		

Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, December

1886.

INDEX TO THE SHEETS OF THE MIRZAPUR SURVEY.



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Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, January 1887.

surveyor can have to contend with. Sickness further retarded the progress of work in this sheet very considerably, and one of the Sub-surveyors succumbed to fever which he contracted while employed on it. Some notes by Mr. Newland on the country surveyed this year will be found in the appendix, page ii.

82. A small drawing office was kept up in the field to work off some arrears of last year's mapping which had accumulated owing to the short duration of the recess season.

83. The party returned to recess quarters at Poona between the 10th and 20th May, and during the recess season the fair mapping has been completed of Sheets 214, 215, 216, 88, 89, and of the greater portions of Sheets 103 and 119, on the 2-inch scale for reduction to one-half. The following sections have been prepared for reproduction to scale—the four complete sections of Sheets 214 and 215 and the N. E. section of Sheet 216. In order to save the labour of extra drawing, the surveyors employed in the Baroda City survey were directed to use every precaution to draw their field sheets neatly and to keep them clean, so that the original sheets might be utilized for the purpose of reproduction. This was successfully carried out, and only one section out of the 16 comprising the whole survey, had to be re-drawn. The printing and finishing of these sections were also completed during the recess. Various maps were in addition prepared and supplied to Colonel Bullock, in connection with the settlement of the Gaekwar's boundary. The large amount of mapping that this party has turned out is very satisfactory, and reflects credit on the Assistants and Sub-surveyors entrusted with its execution. The computations connected with the triangulation and traversing of the year have all been completed and the general reports of Degree Sheets X and XI have been prepared, while some progress has been made with that of Degree Sheet II.

84. During the ensuing season the party will be divided into two sections of equal strength—one section will continue the topographical survey of Gujarát on the 2-inch scale, and will be employed in the following work :—Sheets 102, 118 and 188 will be triangulated; Sheets 86 and 87, part of the Baroda territory in 188, and the unfinished portions of Sheets 190 and 187 will be topographically surveyed, while the boundaries in Sheets 127, 129, 130, 152 and 153 will be traversed for the Baroda Government. The other section will commence the survey on the 8-inch scale of the forest reserves in the southern half of the Thána Collectorate, commencing in the Karjat, Kalyan and Sálsette talukas.*

MIRZAPUR SURVEY.

85. Lieutenant-Colonel Wilmer having been transferred on 1st October 1885 to the charge of the Baluchistan Party, the charge of the Mirzapur Party was temporarily left in the hands of the senior Assistant, Mr. L. J. Pocock, pending the arrival of Mr. Patterson, then in charge of the Malwa Survey.

Personnel.

Mr. W. H. Patterson, Offg. Deputy Superintendent, 4th grade, in charge from 11th November 1885.
Mr. L. J. Pocock, Surveyor, 3rd grade.
„ W. W. McNair, Surveyor, 3rd grade (1st July to 30th September 1886).
„ C. F. Hamer, Surveyor, 4th grade.
„ C. D. Potter, do., do.
„ H. T. Kitchen, Assistant Surveyor, 1st grade.
„ W. H. Lilley, Assistant-Surveyor, 1st grade (transferred 1st May 1886, died 13th May 1885).
„ R. F. Warwick, Assistant Surveyor, 2nd grade (transferred 1st November 1885).

Sub-surveyors.

Azim Khan, Prem Raj, Barkat Ali, Gurdutt Singh, and 10 others. | Kistodhan Chatterjee, Writer, and 6 Computers and Draftsmen.

Two student soldiers—Lal Sing, 19th Bengal Cavalry, and Bhoop Sing, 28th Punjab Infantry (transferred 1st November 1885).

86. The operations of the season under report may be summarized as follows :—

(*a*) Detail survey on the scale of 2 inches=1 mile, with the triangulation required for the same;

(*b*) Skeleton survey of the village boundaries (by running theodolite traverses) in the Dúdhi Pargana, for revenue purposes, on the scale of 16 inches=1 mile;

(*c*) Theodolite traverses fixing village tri-junctions in the Bhadohi Pargana, for utilizing the 16-inch

* Mr. Newland reports: "I am much obliged to all the assistants of the party for their zealous aid and hearty co-operation during the time I have been in charge; the willing and cheerful way in which they have performed their various duties is highly commendable. Mr. S. Norman has done most excellent service in the Drawing Office. To Mr. C. Norman I am greatly indebted for the copious notes furnished by him. The Sub-surveyors have also worked very well."

scale village plans of the settlement in the compilation of the sections of certain sheets which were not to be surveyed in detail;

(*d*) Bringing up of the records and General Reports of the Bhopal and Malwa, and of the Khándesh and Bombay Native States Surveys, which had been left incomplete (see paragraphs 89 and 95 of the Annual Report for 1884-85).

87. Under head (*a*), 487 square miles of detail survey were executed, completing the north-east and south-east sections of Sheets 184 and 185 and the north-west and south-west sections of Sheet 200; and 194 square miles of triangulation in Sheets 184 and 199 was done. The former was rigorously tested in the field, either by the executive officer or by one of his assistants, and in nearly every instance found to be correct. There are now about 250 square miles of ground triangulated in advance of the detail survey in Sheets 199 and 212.

88. The operations noticed under head (*b*) have now been completed. During the season under report, the theodolite was set up at 180 stations, embracing 38·6 linear miles of traverse. This work was begun in 1883: it covers an area of 646·8 square miles, including 205 villages, the boundaries of which have been plotted on 721 sheets. The records of these operations have been finally deposited in store at Dehra Dun.

89. The entire cost of the Dúdhi Survey from first to last has been calculated at ₹39,000, giving the rate per square mile of ₹60·5 and per village of ₹190·5.

90. Under class (*c*), the work involved the setting up of the theodolite at 6,419 stations, embracing 1172·6 linear miles of traverse; and an examination of the settlement village maps shows that, with the help of the traverses now run, they can be utilized for the compilation of the sections of sheets 168, 169, 181 and 182. As a check on the bearings of the traverse lines, astronomical azimuths were observed at 10 stations.

91. Owing to the large quantity of mapping that remained unfinished in 1884-85, and which involved the re-examination of six sections of 2-inch scale survey drawn in that year, and the examination and finishing up of no less than 532 of the 721 sheets of the Dúdhi Survey, the mapping of the field work now reported on unfortunately did not make as much progress as it otherwise would have done. Sections 184 S.E., 185 N.E. and S.E., and 200 S.W. have been partially drawn *in outline*, the object being to show the hills on the final map in brown by double printing, as has recently been done in the case of the large scale map of Jeypore. The completion of these outline maps, as well as the compilation of the sections of the four sheets named under class (*c*), will form part of the work to be done in the coming field season.

92. Under class (*d*) the following has been done:—(1) The General Report for Degree Sheet No. IX of the Bhopal and Malwa Survey has been completed and bound, but a little work remains to be done to complete the duplicate copy of certain of the records appertaining thereto; (2) the General Report for Degree Sheets Nos. VIII and IX of the Khándesh and Bombay Native States Survey has also been completed, and considerable progress made with that of Degree Sheets Nos. III and VI of the same survey; and (3) the angle books of both the Bhopal and Malwa and of the Khándesh and Bombay Native States Surveys have all been examined, completed and forwarded to Calcutta for final deposit.

93. The ground surveyed on the 2-inch scale during the past season was, as usual, very intricate and covered with jungle, the only new feature being that more villages were met with this season along the banks of the Son river and the Rewah boundary. Ferries across the Son exist at Patera, Ghoria, Kotah and Silpi, and across the Rihand at Obre, where the main road crosses from Robertsganj *viâ* Chopan to Khairwa.

94. Owing to the frequent showers of rain which fell during the field season, not only was the health of the party maintained, but the supply of water, which usually runs short in March and April, was duly replenished.

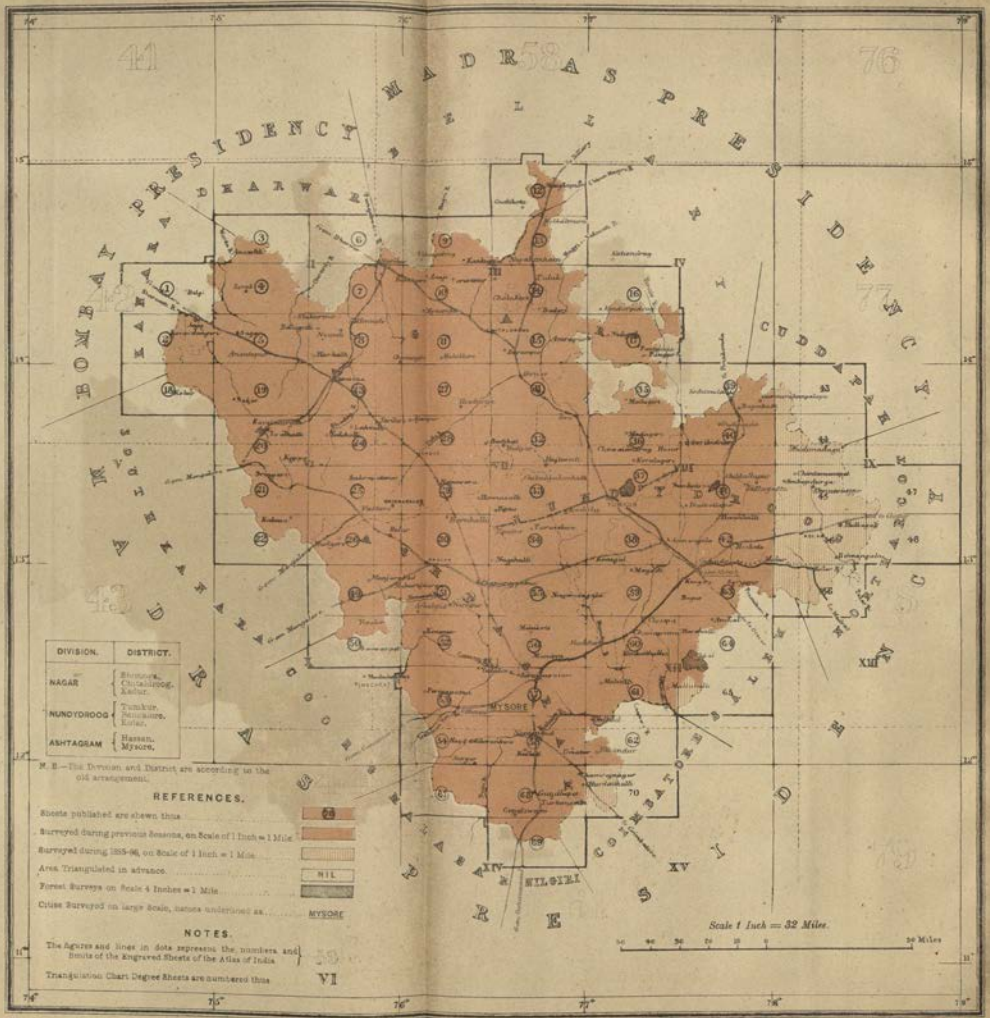
95. The programme of field work for the ensuing season is, *firstly*, to complete the triangulation required in sheets 197 and 198 (about 400 square miles), and detail survey on the 2-inch scale in sheets 198, 199, and 212 (about 500 square miles); *secondly*, to complete the boundary survey of 10 villages in Pargana Bijaigarh (left incomplete by the Revenue Survey Party under Colonel

No. 8 TOPOGRAPHICAL PARTY.

INDEX TO THE SHEETS OF THE MYSORE TOPOGRAPHICAL SURVEY,

To accompany Surveyor General's Report for 1885-86

On the Scale of 1 Inch = 1 Mile.



Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., Officiating Surveyor General of India,
Survey of India Offices, Calcutta, November 1886.

Anderson); and *thirdly*, to take up and finish the main and village circuit traverses in the Chakia Estate (about 120 square miles) of the Maharaja of Benares, for the execution in 1887-88 of a cadastral survey of the tract, the cost of which the Maharaja has agreed to pay for at R160 per square mile, exclusive of the cost for the printing of the maps.

96. It is expected that the field work of this party in the Mirzapur District will be completed in 1887-88.*

MYSORE SURVEY.

97. The field operations of this party were conducted by Major McCullagh, R.E., who remained in charge until 23rd March 1886, when he was compelled by ill-health to take leave to England. He was relieved by Lieutenant H. M. Jackson, R.E., who has held the executive charge from that date.

Personnel.

Major J. R. McCullagh, R.E., Officiating Deputy Superintendent, 3rd grade, in charge, up to 23rd March 1886.
Lieutenant H. M. Jackson, R.E., Officiating Deputy Superintendent, 4th grade, in charge, from 23rd March 1886.
Mr. A. J. James, Surveyor, 4th grade.
„ F. Kitchen, ditto, ditto.
„ H. Todd, ditto, ditto.
„ J. A. Barker, Asst. Surveyor, 1st grade.
„ R. Todd, ditto ditto.
„ J. M. Kennedy, ditto 2nd grade, up to 14th June 1886.
„ T. J. J. Mills, Assistant Surveyor, 3rd grade.

Sub-surveyors.

Janki Dass. | Raghavayengar. | Tiruvenkatsami and 7 others.

98. The portion of country that remained for survey had been previously triangulated, so that the field operations during the season under report were confined to detail survey on the standard scale of 1 inch = 1 mile. A small detachment, consisting of one Surveyor and four Sub-surveyors was kept in recess quarters to bring up the Degree Reports, &c., while the rest of the establishment proceeded to the field early in November 1885. The field work progressed steadily until the completion of the survey in the middle of April 1886.

99. The area topographically surveyed amounts to 2,570 square miles on the scale of 1 inch = 1 mile, the greater portion of which lies in the Kolar District; the remaining portion being on the south-east frontier of the province in Sheets 65 and 70. The nature of the country surveyed in Kolar is typical of the open and undulating parts of the province which have been described in previous reports, and which present no great difficulties to the surveyor. The country in Sheets 65 and 70, however, presented serious obstacles to rapid progress. The portion of the Chamrajnagar and Yelandur frontiers is the most mountainous part of Southern Mysore, being in fact the lower steps of the Nilgiri plateau. A great part is covered with dense jungle, and this, combined with the long grass which grows all over the hills, except on the higher peaks, renders even locomotion most difficult. A few notes on the country plane-tabled will be found in the appendix, page ii b.

100. The field plans of the detail survey were carefully tested almost entirely by Major McCullagh, and their accuracy was fully established. One section in Sheet 70 was unavoidably not regularly examined owing to the distance that the examiner would have been obliged to travel. It was surveyed, however, by an European assistant of long experience and tried ability, in whose integrity there is every confidence. A great portion of the ground was, however, subsequently gone over with a trace of the sheet, by Lieutenant Jackson while on privilege leave, and the features were found to be well represented.

101. During the recess season the fair maps of the area completed have been prepared in 9 standard-sized sheets; 6 Degree Charts of triangulation were revised, corrected and completed, and 12 quarter sheet reductions to the scale of the Atlas of India were prepared. The General Reports of 7 Degree Sheets were completed and thus the whole of the records connected with the Mysore survey were brought to a satisfactory termination by the 1st October 1886.

* Mr. Patterson reports favourably of all his assistants, excepting two Sub-surveyors, whose services have been dispensed with.

102. The area of the Mysore State proves to be 29,305 square miles, which is over 2,000 square miles in excess of the estimated area. In addition to this, a strip of the country has been surveyed outside and all round the State boundary, averaging about a mile in width. This aggregates 1,634 square miles, so that the total area which has been surveyed on the 1 inch = 1 mile scale amounts to 30,939 square miles. The mapping of the same is contained in 70 standard sheets, 4 sheets of Reserved Forest Surveys and 19 sheets of Cantonment and City Surveys.

103. The survey was commenced in November 1875, and has thus taken eleven years to complete. The original desire of the Local Administration was that the survey should be completed in five years, and with this object, two full topographical parties were organized and sent to Mysore. Unfortunately at the very outset of the operations, unexpected and serious difficulties were met with in consequence of the famine and drought which prevailed in Mysore, and nearly throughout the southern peninsula during 1876 and 1877. Owing to the distressed state of the country it was found impossible to utilize and keep the establishment in full employment on survey work. Measures were then adopted to place at the disposal of the Public Works Department for employment on relief works every assistant whose services could not be utilized on survey; and nine European Surveyors and several Sub-surveyors were thus transferred temporarily. On financial grounds it was also decided that only one party should be employed in future on the survey; so in November 1877, reductions were enforced, and the reduced parties were combined and formed into one party of ordinary strength with which the survey has been since accomplished. Thus for the first three years, during which the country laboured under famine difficulties, the progress of the general survey was unavoidably much retarded, the out-turn of topography during that period being only 4,701 square miles; the completion therefore of the remaining large area of 26,238 square miles in eight years is highly satisfactory and creditable to all concerned in the survey, especially so when the very difficult nature of a considerable portion of the country is taken into consideration.

104. The total cost of the survey amounts to R9,07,626, which gives an average mileage rate of R29-5-4 over the whole area of survey; but the cost includes surveys on the 4-inch scale of 84 square miles of State forests, and on the 12-inch scale of 57 square miles comprising the city of Mysore and the cantonment and city of Bangalore. The average mileage rate was of course considerably enhanced by the slow progress of the first three years of the survey for the reasons given above, which were totally beyond the powers of prevention of the Survey Department.

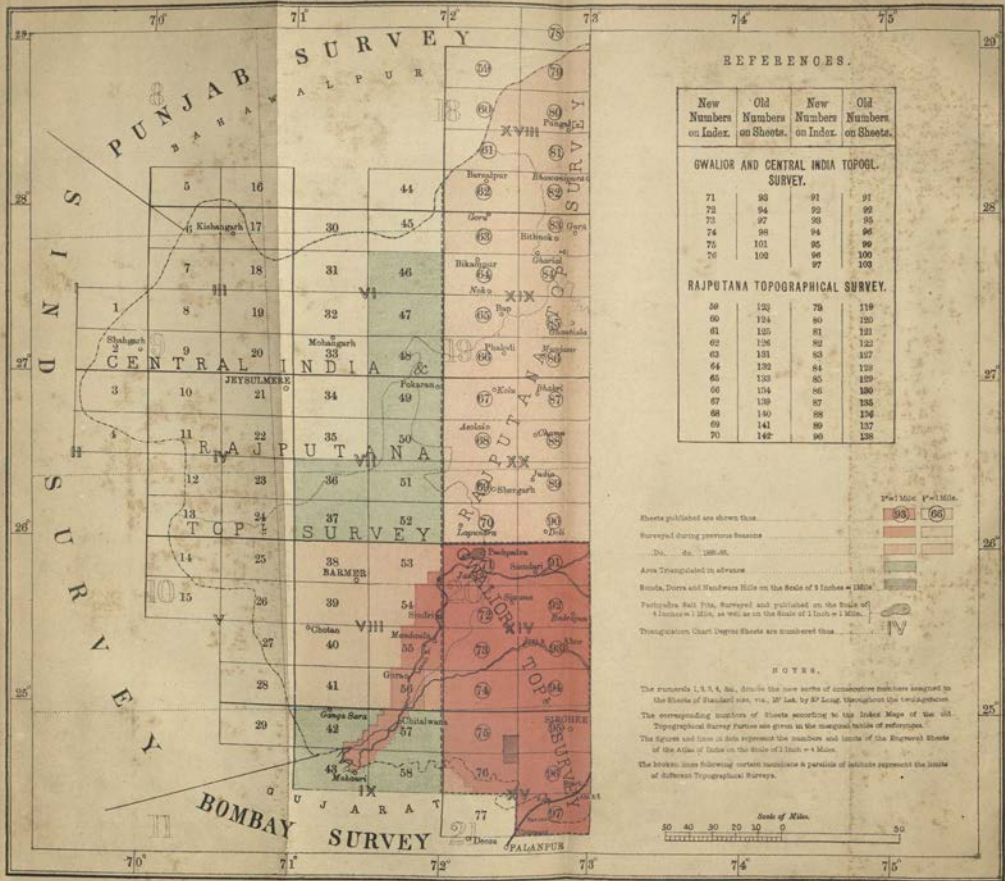
105. The entire cost of the Mysore Survey has been borne by the Mysore State. From 1st October 1886, however, the expenditure of the party has been included in the Imperial Estimates.

106. The negotiations with the Madras Government for the transfer to the Survey of India Department of the topographical portion of the work of the Madras Survey Department having been successfully concluded, the Mysore Party has been transferred to the Madras Presidency to undertake this work. The tracts of country that have been made over form portions of the following districts, *viz.*:—Ganjam, Vizagapatam, Tinnevelly, Madura, South Canara and Malabar and comprise an aggregate area of about 12,400 square miles, which is to be surveyed on the scale of 1 inch = 1 mile. The surveys of forests in the above districts, with the exception of those in Ganjam and Vizagapatam, will also be undertaken on the scale of 4 inches = 1 mile, and the cost thereof debited to the Provincial revenues in accordance with the rules prevailing in this department.

107. The Districts of Tinnevelly and Madura have been selected for the operations to be commenced in, and the late Mysore Party, now designated the "Madras Party," has proceeded from Bangalore to Madura and will be employed during the current field season in the topographical survey of the hill portions of those districts.*

* The assistants, both European and native, are very favourably reported on for their application, industry and willingness.

INDEX TO THE SHEETS OF THE RAJPUTANA TOPOGRAPHICAL SURVEY.



New Numbers on Index.	Old Numbers on Sheets.	New Numbers on Index.	Old Numbers on Sheets.
GWALIOR AND CENTRAL INDIA TOPOGL. SURVEY.			
71	93	91	91
72	94	92	92
73	97	93	95
74	98	94	96
75	101	95	99
76	102	96	100
		97	103
RAJPUTANA TOPOGRAPHICAL SURVEY.			
59	123	79	119
60	124	80	120
61	125	81	121
62	126	82	122
63	131	83	127
64	132	84	128
65	133	85	129
66	134	86	130
67	139	87	135
68	140	88	136
69	141	89	137
70	142	90	138

	1"=1 Mile.	4"=1 Mile.
Sheets published are shown thus	93	66
Surveyed during previous Seasons		
Do. do. 1886-87.		
Area Triangulated in advance		
Sands, Dunes and Nucleus Hills on the Scale of 8 Inches = 1 Mile		
Pachpadra Salt Pits, Surveyed and published on the Scale of 4 Inches = 1 Mile, as well as on the Scale of 1 Inch = 1 Mile.		
Triangulation Chart Degree Sheets are numbered thus	IV	

NOTES.

The numerals 1, 2, 3, 4, &c., denote the new series of consecutive numbers assigned to the Sheets of Standard size, viz., 15' Lat. by 15' Long. throughout the two Atlases.

The corresponding numbers of Sheets according to the Index Maps of the old Topographical Survey Parties are given in the marginal tables of references.

The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of Index on the Scale of 1 Inch = 4 Miles.

The broken lines following certain meridians & parallels of latitude represent the limits of different Topographical Surveys.

Scale of Miles.

50 40 30 20 10 0 50

Published under the direction of Lieut. Colonel H. H. Thuillier, R.E., *Officiating Surveyor General of India, Survey of India Office, Calcutta, February 1887.*

Photozincographed at the Survey of India Office, Calcutta.

RAJPUTANA SURVEY.

108. The operations of the party during the year were as follows :—

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Deputy Superintendent, 4th grade, in charge till 1st April 1886.
Lieutenant W. H. Pollen, R.E., Officiating Deputy Superintendent, 4th grade, in charge from 1st April.
Mr. W. Todd, Surveyor, 2nd grade.
„ N. C. Gwynne, ditto 3rd do.
„ G. P. Tate, Asst. Surveyor, 2nd do.
„ M. Gastand, ditto 2nd do.
„ P. Beechey, ditto 2nd do.
„ C. G. S. Wood, ditto 3rd do.

Sub-surveyors.

Shah Nasiruddin, Sheikh Omar, F. Rosario, | Abdul Gufár, Golam Mahomed, Abdul Aziz, and four others.

(*a*) The ordinary detail survey on the ½-inch scale of Sheets Nos. 38 to 41, 53 to 55, and ⅛ of 56 comprising Degree Sheet VIII, embracing portions of Jodhpore and the Maláni District near Bármer and the Lúni River; also on the 1-inch scale of the south-west corner of Standard Sheet No. 76, where the boundaries of the Jodhpore, Sirohi, and Pálanpur States join, and the eastern quarter of No. 56, so as to complete Degree Sheet VIII.

(*b*) The triangulation in advance over Sheets Nos. 36, 37, 43, 58 and 46 to 52.

(*c*) The verifying and correcting of the large number of village boundary maps of the Ajmere-Merwára District, and the revision and bringing up to date of the 1-inch map of the same district.

109. The field season lasted from 1st November 1885 to the 10th May 1886. The out-turn of topography on the ½-inch scale was 3,540 square miles, and on the 1-inch scale 256 square miles. The triangulation in advance covered 5,850 square miles, of which 4,810 square miles in Degree Sheets VI and VII were prepared for ½-inch, and 1,040 square miles in sheets 43 and 58 for 1-inch detail survey. The revision of the Ajmere-Merwára village boundary sheets and the completion of the 1-inch maps of the district has been satisfactorily carried out; and it is gratifying to find that, with one unimportant exception, the original survey was found to be very accurate and complete, so far as the then existing details were concerned; but of course additions had to be made showing the railway and new roads and tanks, &c., which have been constructed since. The out-turn of triangulation would have been considerably greater had not intimation been received that the party would be employed next season in Baluchistan; it was therefore necessary to warn the two assistants engaged on triangulation to square off their work, and help in the execution and examination of the detail survey.

110. The country surveyed is mostly open, but very sandy, with rocky hills to be met here and there, running up to 2,000 feet above sea level. There was generally a difficulty in obtaining drinking water. The River Lúni runs through the eastern portion of Degree Sheet VIII, and on each side of it is the *nayar* land—a black alluvial soil brought down by the river, on which the inhabitants grow wheat: this land is as much as 14 miles in width near the Ran of Cutch. The important places met with were as follows:—The towns of Bármer, the head quarters of the district; Maláni, the residence of the chief of the district; Guranagar on the Lúni, the chief of which has a remarkably fine breed of horses; Sindri on the Luni; and Pokaran, the residence of the chief of the district, in the vicinity of which are some stone quarries.

111. The services of Lieutenant-Colonel Beavan having been required at Calcutta early in April, Lieutenant Pollen was transferred to the charge of the party on the 1st April. The latter officer has therefore conducted the recess duties which may be summarised as follows:—The fair mapping of Sheet No. 76 on the 1-inch, and of the northern and southern halves of Degree Sheet VIII on the ½-inch scale; the fair drawing (for use of engravers) of Sheet No. 21 N. E., quarter of the Indian Atlas, has been well advanced: the chart of the Jeypore and Amer (Amber) triangulation has been completed, while those of Degree Sheets XIV and VIII (for general reports) have been partially done: the General Report of Degree Sheet XIII has been completed, and that of XIV is about three-quarters finished; while the computations of VIII have been examined and set in order, so as to readily furnish the numerical results required for the General Report. For the Ajmere-Merwára revision, the corrections have

been plotted on some 330 16-inch village boundary maps; and having further been reduced, have been transferred to the 1-inch sheets of the district.

112. The party being under orders for transfer to Baluchistan, it was an object to keep in view the more urgent work of bringing up the arrears and squaring off the work as far as possible and the computations of the past field season could not be taken up.

113. The health of the party generally has been good; but the native establishment employed near the Ran of Cutch suffered a good deal from fever.

114. Captain R. A. Wahab, R.E., has now been transferred to the charge of this party, which will be termed No. 16 (Baluchistan II) Party, and Lieutenant Pollen to the South Marátha Party in Bombay.

115. The programme for next field season was at first arranged as follows:— The triangulation in Baluchistan of Sheets No. 22 N.W. and S.W., and the detail survey on the $\frac{1}{2}$-inch scale of portions of Sheets 22 N.E. and S.E.; but in consequence of an urgent demand from the Military Department, the operations will be confined chiefly to special large scale surveys in the neighbourhood of Peshin and Quetta. The extension southwards of the 2-inch survey of the Khwája Amran Range, so as to include the Wach Darra pass, will also be undertaken.

116. Extracts from Lieutenant Pollen's Narrative Report, as well as an account of the country triangulated by Mr. Tate are given on pages iii and iv of the appendix.*

SOUTH MARATHA SURVEY.

(No. 10 Party, Revenue Branch.)

117. This party, lately employed on the survey of the Thána and Kolába Districts, changed its ground, as indicated in paragraph 82 of last Annual Report, to the south of the parallel of 16° N. Latitude, to undertake, partly, a general topographical survey on the 2-inch scale, and, partly, a skeleton traverse survey of the forests, designed to serve as a basis for the construction of working plans by Forest Officers. The field season commenced during the last week in November 1885, and closed for the main body of the party on 25th May, though some detachments remained at work until 10th June.

Personnel.

Major J. Hill, R.E. Deputy Superintendent, 3rd grade, in charge from 23rd October to 28th December 1885.
Lieutenant F. B. Longe, R.E., Officiating Deputy Superintendent, 4th grade, in charge up to 22nd October 1885 and from 29th December 1885.
Mr. J. Peyton, Surveyor, 1st grade, up to 30th June 1886.
„ A. M. Lawson, Surveyor, 2nd grade.
„ W. M. Kelly, Assistant Surveyor, 1st grade.
„ R. R. Dickinson, Assistant Surveyor, 1st grade, from 17th May 1886.
„ O. D. Smart, Assistant Surveyor, 2nd grade, from 14th October 1885.
22 Sub-surveyors, and others.

118. The topographical operations were chiefly confined to the Belgaum District, but parts of Native States, namely, Karundvad Kolhápur, Sángli and Sávantvadi, and of the Dhárwár District, were also surveyed. The areas are shown in the following statement:—

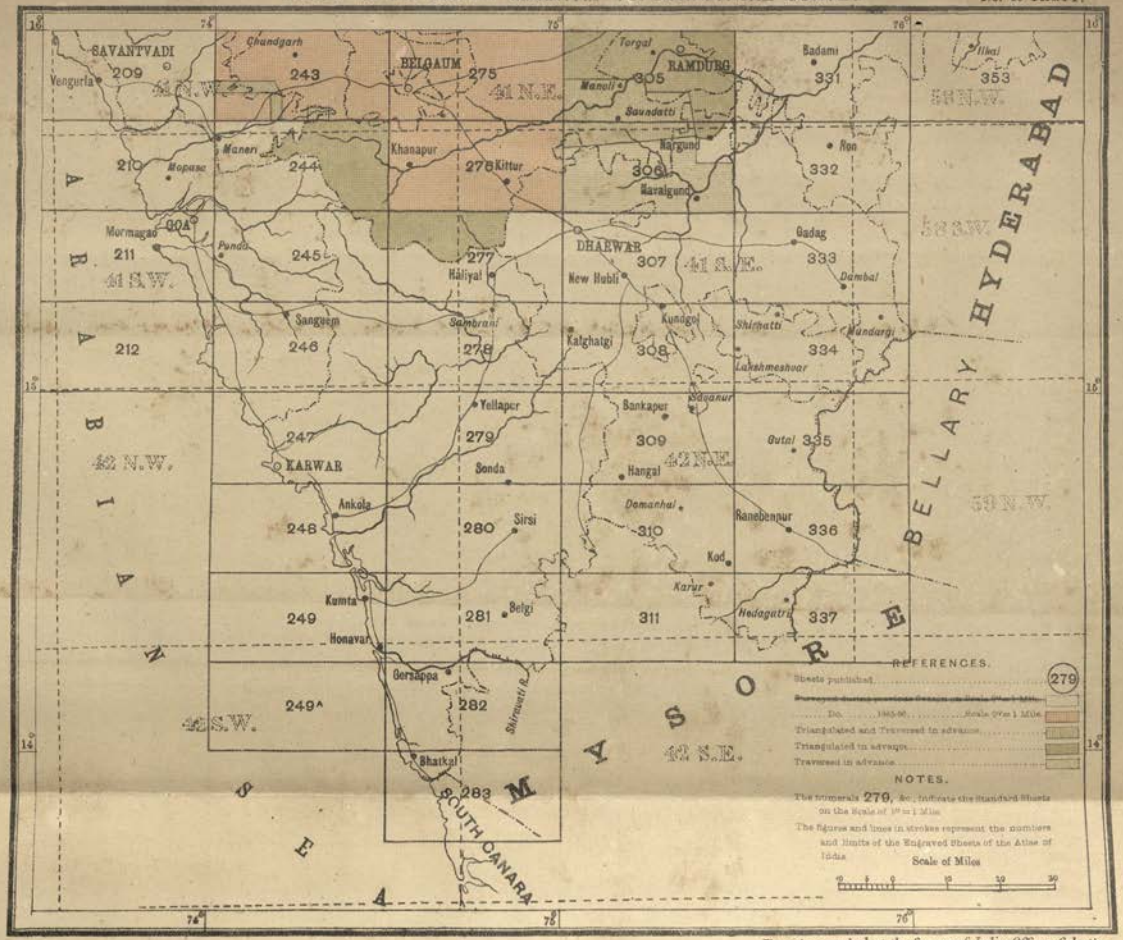
	Square miles.
Belgaum District	1209·9
Dhárwár „	76·2
Karundvad State	113·3
Kolhápur „	6·7
Sángli „	111·0
Sávantvadi „	154·9
Total	1672·0

* The Officer in charge reports well of all his assistants, mentioning Mr. Gwynne in particular.

BOMBAY SURVEY.

INDEX TO THE SOUTH MARATHA TOPOGRAPHICAL SURVEY.

No. 10 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India,*
Survey of India Offices, Calcutta, December 1866

The areas triangulated and traversed are 1,210 and 2,316 square miles respectively, of which 850 and 600 square miles are in preparation for next season's topography.

119. By the triangulation, 337 points have been fixed, of which the heights of 306 have been determined; and there are 3,231 traverse stations, 583 of which have been fixed on village tri-junctions. The ground was surveyed as closely as possible, and the accuracy of the details was tested by 124 linear miles of check surveys, as well as by "*in situ*" examinations by the executive officer and by two of his European assistants.

120. The sheets topographically surveyed are Nos. 243, 275 and 276, but of Sheet 243 a small area remains chiefly on the *ghâts*, from which the surveyors were driven away through the setting in of the rains. The country surveyed is of a varied character. In the west, the *ghâts* with their scarps and deep ravines, the whole being covered with forest, rendered the work difficult and laborious, but with the exception of 8 plane-table sections in the *ghâts* the work was easy. In the west of Sheet 276 the country is covered with forest, and in 275 the hills are covered with thorn bushes which made chaining very troublesome. Belgaum with its cantonment and fort fell within the area surveyed, but there is no other place of any great importance, though to the district generally a good deal of historical interest is attached. Some descriptive notes furnished by Lieutenant Longe are given in the appendix, page vi.

121. The forest surveys were exclusively carried on in the Khánápur Taluka of the Belgaum District, and were found to constitute a work of considerable difficulty, as not only was the amount of traversing, required to enclose the forest blocks, very large on account of the boundaries being irregular, while patches of cultivated land which also had to be traversed were interspersed within the forests, but the true boundaries were imperfectly known to the village people, and consequently much delay occurred in searching through the records for information regarding them. The detachment available to be sent into the forests this season was small, and the surveys could not be begun until February after the exact character of the work to be done had been ascertained from the Forest Department. Thus, through the difficulties and delay, the Forest maps of only six villages have been completed, but six more villages have been surveyed and are only awaiting the revision of one of the main traverses to be plotted. The maps are to show all made roads which run through the forests and all perennial streams, as well as all permanent structures, such as temples or survey stations.

122. Next season the forest survey section will be strengthened and made equal to the topographical survey section, and in the first instance the work will be undertaken within a triangle with Khánápur as its apex and the line between Londa railway station and Linganmat as its base, which is the tract specified by the Forest Officers for their immediate requirements. The tract has been triangulated in preparation for the forest traversing.

123. The health of the party was on the whole good, and there were only two serious cases of sickness. The squads working in the forests suffered most, and at one time there was an average of 75 per cent. sick in the Khánápur forests, but this was late in the season after the rains had begun.*

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* Lieutenant Longe mentions that Mr. J. Peyton, Surveyor, 1st grade, suffered from fever during the field season, which for some time incapacitated him from work. Mr. Peyton retired from the department on a superannuation pension on 1st July after a service of 39 years. He had acquired considerable proficiency as an artistic draftsman.

Lieutenant Longe also reports :—Mr. A. M. Lawson again maintained his high reputation, * * * * * * * he is a man of the highest value in a party, setting every one in it an example of hard, honest work, cheerfully performed."

"Mr. W. M. Kelly * * * * both in the field and in office has worked very well." Mr. R. R. Dickinson * * * * is a most careful and trustworthy assistant. Mr. O. D. Smart * * was employed on the forest work. He had many difficulties to contend with, but by care and perseverance he managed to overcome them * * * * his work is accurate and very neatly done.

Lieutenant Longe reports that Fyzoolah Khan, Sub-surveyor, has done very good work and also mentions favorably the names of the following other members of the native establishment, *viz.*, Damodar Gopal, Nursoo Limbadry, Gobind Janardhan, Inamulla Khan, Ramrao Yadhao, Babaji Ramchandra, Muksudi Lall, Abdul Ghani Khan.

FOREST SURVEYS.

BURMA FORESTS.

124. The party, of strength noted in the margin, left recess quarters at Rangoon in two detachments; the one comprising the triangulation and traverse camp on the 20th November, and the other the detail survey camp, on the 28th November 1885. The former section was employed in the Prome District and the latter section in the Tharrawaddy District, and the field operations were continued until 26th April, when they were obliged to be stopped abruptly, owing to the disturbed state of the country.

Personnel.

Mr. H. Hörst, Deputy Supdt., 3rd grade.
" J. H. Wilson, Asst. Surveyor, 1st grade,
" C. P. Torrens " "
" W. H. Penrose " "
" R. A. Gibson " "
" W. H. Ewing " 2nd grade,
(from 1st October 1885).

Sub-surveyors.

Venkat Swamy.	Ahmad Sayid, transferred to Mandalay, 1st April 1886.
Sher Shah.	Sharfuddin
Doorgiah.	Girdhari Lal, and 14 others and 2 Apprentices.
Sumer Sing.	
Rahmat Ali.	

125. The triangulation has been extended over an area of 263 square miles, embracing both reserved and unreserved forest tracts, and nearly the whole of this area has been covered by the traverse survey.

126. The traverse survey covered an area of 345 square miles. This, together with 190 square miles remaining over from the previous season, gives 535 square miles of advance work, of which 255 square miles will be required to be surveyed on the scale of 4 inches = 1 mile, and 280 square miles on the scale of 2 inches = 1 mile.

127. The area surveyed in detail extended over 330 square miles, exclusive of 24 square miles of overlap. Of this out-turn, 199 square miles, consisting entirely of reserved forests, were done on the 4-inch scale, and 131 square miles comprising unreserved forest tracts on the 2-inch scale. The operations extended over the greater portion of the tracts drained by the Taungnyo River in the Tharrawaddy District, and the Shwele River in the Prome District; also over a portion of the Shwedaung hills, stretching due south of Prome.

128. The ground surveyed on the 4-inch scale was for the most part mountainous, very intricate, and covered with dense jungle; that done on the 2-inch scale consisted of low intricate hills, cut up with innumerable water-courses and covered with heavy jungle.

The out-turn of work is considerably less than that of the previous season, and consequently the average mileage rate has been enhanced, but this is fully accounted for—

(i) by the duration of the field season being nearly a month shorter than usual owing to the disturbed state of the country which prevented the continuance of field work;

(ii) by changes of programme during the season due to the necessity of withdrawing the surveyors from the Yoma Forest, in which dacoits were committing depredations;

(iii) by interruptions caused on other occasions by dacoits which involved a considerable loss of work;

(iv) by the transfer of two Sub-surveyors for work in Upper Burma;

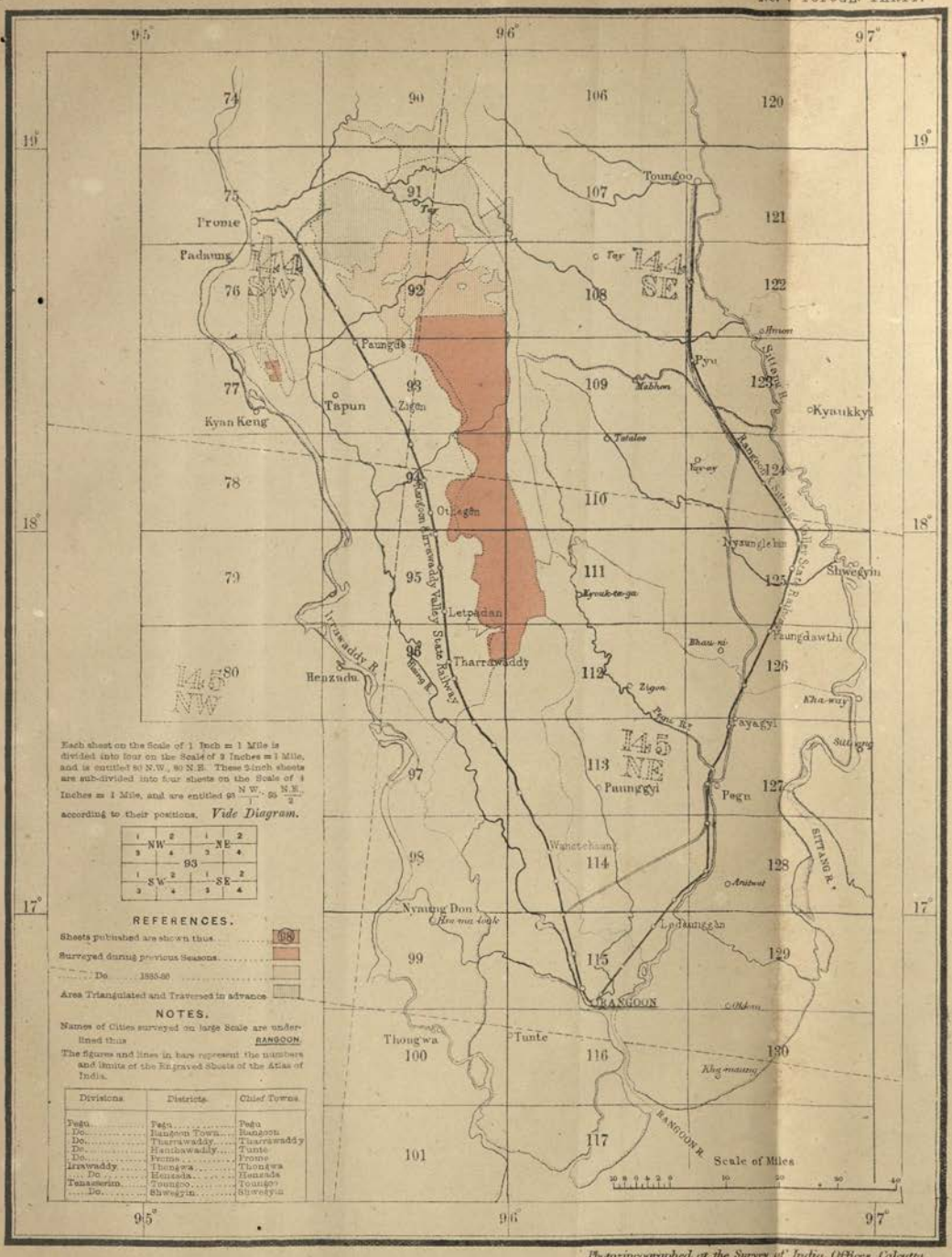
(v) by the unusual unhealthiness of the season.

129. Up to date the total area which has been surveyed is 1,044 square miles, excluding re-survey and overlap, of which 817 square miles are on the 4-inch scale, and 227 square miles on the 2-inch scale.

130. During the past season the Assistants and Sub-surveyors suffered more than usual from malarious fever, but the *klassies* kept their health very well. The total number of days lost from sickness was 317, representing the loss of the services of more than two men per month, or in other words, of 40 square miles on the 4-inch scale.

INDEX TO THE SHEETS OF THE BURMA SURVEY.

No. 7 TOPOGL. PARTY.



Each sheet on the Scale of 1 Inch = 1 Mile is divided into four on the Scale of 2 Inches = 1 Mile, and is entitled 93 N.W., 93 N.E. These 2inch sheets are sub-divided into four sheets on the Scale of 4 Inches = 1 Mile, and are entitled 93 $\frac{N.W.}{1}$ $\frac{N.E.}{2}$ $\frac{S.W.}{3}$ $\frac{S.E.}{4}$ according to their positions. *Vide Diagram.*

1 NW 2 / 3 4	1 NE 2 / 3 4
93	
1 SW 2 / 3 4	1 SE 2 / 3 4

REFERENCES.

Sheets published are shown thus 98

Surveyed during previous Seasons .....

Do. 1885-86 .....

Area Triangulated and Traversed in advance .....

NOTES.

Names of Cities surveyed on large Scale are underlined thus RANGOON.

The figures and lines in bars represent the numbers and limits of the Engraved Sheets of the Atlas of India.

Divisions.	Districts.	Chief Towns.
Pegu	Pegu	Pegu
Do.	Rangoon Town	Rangoon
Do.	Tharrawaddy	Tharrawaddy
Do.	Hanthawaddy	Tunte
Do.	Prome	Prome
Irrawaddy	Thongwa	Thongwa
Do.	Henzada	Henzada
Tenasserim	Toungoo	Toungoo
Do.	Shwegyin	Shwegyin

Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, January 1887.

131. Extracts from Mr. Hörst's report, which will be found in the appendix, deal in detail with the delays and difficulties he met with, and under the exceptional circumstances, the out-turn is as much as could have been expected.

132. There were five casualties among the menial establishment caused by dacoits, and one of the European assistants, Mr. Gibson, when returning to quarters, was attacked by a large band of dacoits at Peinzaik, who plundered his camp, and a considerable amount of both Government and private property was thus lost. Fortunately Mr. Gibson escaped unhurt, and as he had taken the precaution to secure the safety of the field maps which had been executed by himself and the detachment during the season, the loss of these valuable records was averted by his forethought.

133. Provision depôts were kept up at five places from 25 to 40 miles from the source of supply. No food of any kind was procurable from the Karens, who, Mr. Hörst states, were plundered by dacoits of all they possessed as early as January; and the Burmans who inhabited a few villages along the Taungnyo and Shwele rivers, either could not, or would not sell any part of their stock of rice.

134. Thirty-one linear miles of check survey were run—not sufficient to test the accuracy of the work—but owing to the abrupt termination of the field season more could not be done. The Assistants and most of the Sub-surveyors were inspected by the officer in charge and the remaining Sub-surveyors by the Assistants in whose vicinity they were at work.

135. During the recess seven complete standard sheets on the 4-inch scale have been drawn, and two sheets as far as the ground has been surveyed; also 9 sheets on the 2-inch scale for reduction to one-half. A triangulation chart has also been drawn, but the printing of the names yet remains to be done. The usual computations, plotting and projection of field sections, &c., for the current season's detail survey have also been done.

136. The programme of operations which was arranged for the current field season is as follows:—The area, 205 square miles, already prepared for detail survey, south and east of Prome, will be taken up first, while a triangulation party will be sent into the Zamayi Reserve in the Pegu Valley for preliminary operations. The triangulation and traverse survey in the Pegu District will be carried on simultaneously in the State Reserves of South Zamayi, Shaudon and Pyeng-ma, which border on the Pegu River and are situated about 40 miles north-west of Pegu.

137. The detail survey operations will be commenced about the 1st December in the Prome District in the Shwedaung hill tract to the south of Prome. Of this, about 60 square miles will be surveyed on the 2-inch scale and 22 square miles, completing the Reserve named Inma Tayokmaw, on the 4-inch scale. The detached Reserves of Daube, Nyaung-Bendet, Pauktan Sinmizwè and Htonyea, aggregating 46 square miles, will also be surveyed on the 4-inch scale, and some tracts which were left unsurveyed last season near Ngapaw in the Paungdé township, aggregating 11 square miles, will be completed on the 2-inch scale.

138. The above programme comprises 68 square miles on the 4-inch scale and 71 square miles on the 2-inch scale, but in addition, about 60 square miles of country contiguous to, and east of that already cadastrally surveyed will be taken up on the 2-inch scale.

139. By the time the foregoing tracts are done, it is expected that sufficient ground will be triangulated and traversed in the State Reserves of South Zamayi, Shaudon and Pyeng-ma to admit of the detail surveyors being moved down from Prome to take up the topography of those reserves on the 4-inch scale.

Since this Report was written it has been found necessary to modify the above programme as regards the work in Prome, owing to the timidity of the Sub-surveyors and klassies, and the impossibility of providing Police guards for all the scattered detachments. On taking the field it was found that in consequence of the presence of dacoits in the neighbourhood of the ground to be surveyed, that it would be futile to attempt to carry out the detail survey of the forests in that tract. With the concurrence of the Chief Commissioner, the work in the Prome District was therefore suspended, and the establishment

*has been drafted chiefly to Upper Burma, where their services can be very usefully employed.**

CADASTRAL SURVEYS.

AKYAB DISTRICT, BURMA.

(No. 7 Party, Revenue Branch.)

140. On the superannuation of Mr. H. B. Talbot (on the 26th October 1885) this party was placed under the charge of Lieutenant-Colonel H. S. Hutchinson. The traversing section of the party was recalled from India somewhat earlier than usual, in order to complete the preliminary boundary work before the arrival of the cadastral section, but little advantage was derived from this early recall, as the country to be operated in was found to be flooded by reason of a late rainy season. The traversing section resumed work on 15th November, and the cadastral section on 5th December. Field work was continued up to 31st May.

Personnel.

Mr. H. B. Talbot, Officiating Deputy Superintendent, 3rd grade, in charge, to 21st October 1885, and superannuated on 26th October 1885.
Lieutenant-Colonel H. S. Hutchinson, S. C., Officiating Deputy Superintendent, 3rd grade, in charge, from 22nd October 1885.
Mr. F. W. Kelly, Officiating Deputy Superintendent, 4th grade, from 15th October 1885.
„ H. R. Littlewood, Surveyor, 2nd grade.
„ G. W. Jarbo, Assistant Surveyor, 1st grade.
„ J. R. Scott, Assistant Surveyor, to 22nd October 1885.
„ J. S. Swiney, Assistant Surveyor, 1st grade.
„ G. S. Willes, Assistant Surveyor, 3rd grade.
18 Sub-surveyors and others.

Temporary Establishment.

97 Field surveyors and others.

141. The main part of the cadastral work of the season lay in tracts bordering the Kaladan and Padu Rivers, in the centre of the district, east and north-east of the town of Akyab, but several detached portions have also been surveyed in two separate valleys in the north-west part of the district, which required the establishment to be very much scattered at the beginning of the season. All the detached tracts of the district to be surveyed cadastrally have now been completed, and the remaining tract for cadastral survey consists of a compact block bordering the Kaladan River. As is usual in Burma, a considerable extent of waste land has been found intermingled with the cultivation, amounting in this season to over 50 per cent. of the total area of 661·29 square miles included in the cadastral survey. The separate areas are shown in the following statement:—

	Square miles.
Cultivation	318·13
Jungle and waste	308·46
River areas	34·70
TOTAL	661·29

The cultivated area includes 6,94,056 fields, of the average size of 0·29 of an acre.

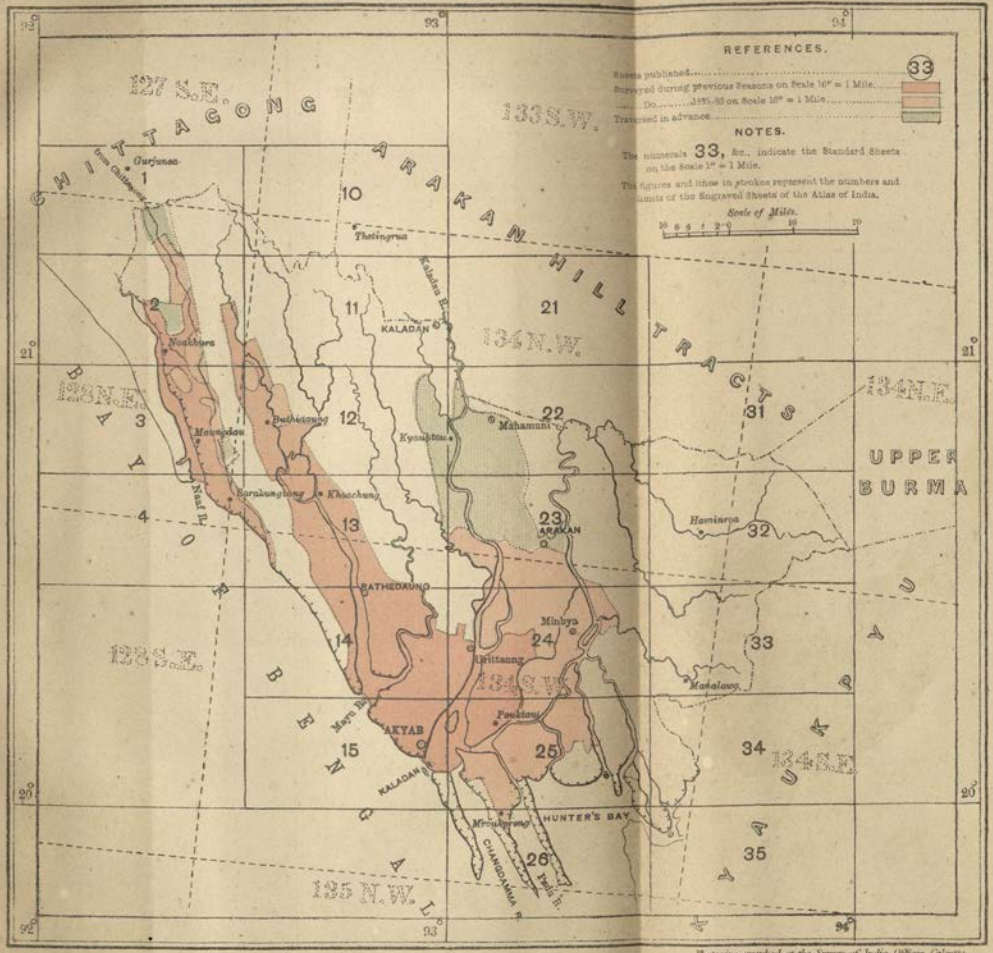
142. Of boundary traverse survey, a total area of 794 square miles was accomplished, of which 469 square miles have been surveyed cadastrally and 325 square miles remain as preparatory work for next season. The chain traverses have been connected with four stations of the Great Trigonometrical Survey and with three other triangulation stations especially fixed for the purpose of additional verification of the chain measurements. Comparisons

* Mr. Hörst reports of his assistants as follows:—Mr. Torrens had charge of the traverse camp and conducted his duties, which were of a harassing nature, in a satisfactory manner. Mr. Gibson, as usual, displayed much energy and devotion to his duties, and surveyed a difficult and dangerous tract. Mr. Ewing, who had no previous experience in triangulation, worked with energy, and was instrumental in having a large gang of dacoits dispersed by leading the Superintendent of Police, Prome District, right up to their encampment. Sub-surveyors Venkat Swamy, Sher Shah, Sumer Singh, Ahmad Sayid, Sharfuddin, Girdhari Lal, and Piari Lal worked very steadily under great difficulties. Sub-surveyor Nasiruddin stood firm and saved much property when a panic occurred among some Sub-surveyors, who forsook private as well as public property in their flight.

LOWER BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTRICT AKYAB.

No. 7 REV. PARTY.



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NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTRICT BASTI.

No. 4 REV. PARTY.

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Survey of India Offices, Calcutta, November 1886.

have thus been instituted with 20 triangulation distances which show the chaining to have an average error of 1·1 foot per linear mile. Observations for azimuth were taken at forty-nine stations.

143. The system of marking a certain number of the traverse stations with stone prisms (which have been adopted for the Akyab District in place of the cylinders of pottery used in other districts in Burma) has been continued; and ordinarily these marks have been put down at all tri-junctions and at stations half a mile apart along the boundaries. As a precaution against the destruction or removal of these marks, notices in Burmese, signed by the Deputy Commissioner, showing the positions of the marks, have been handed to the headmen of villages, holding them responsible for the preservation of the marks.

144. The season, especially at its commencement, was an unusually unhealthy one. Only 12 deaths actually took place in the field, but 57 men of different classes were invalided to India, and the average of the sick who were absent from duty was 26 daily throughout the whole season.

145. The number of the cadastral sheets of the season is 915, which, as usual, are being retained in the party office awaiting Settlement revision before being sent to Calcutta to be printed. The sheets of the previous season, 946 in number, were sent up to Calcutta as they were got ready after revision and were all printed off by the end of November 1886. The general maps on the 2-inch scale will be drawn in the party office, and the traverse stations have been projected on 28 of them.

146. A short descriptive sketch of the features of part of the Akyab District and of one of the exciting amusements of the inhabitants, furnished partly by Colonel Hutchinson and partly by Mr. Jarbo, is given in the appendix, page x.*

BASTI DISTRICT, NORTH-WEST PROVINCES.

(No. 4 Party, Revenue Branch.)

147. This party resumed operations in the Basti District in continuation of its work of last year. No changes were made in the system of survey or in the preparation of the settlement records and statistics, with the exception that a slight modification of soil classification was introduced by the Settlement Officer on the 4th January 1886. Field work was commenced on the 20th October 1885, and closed on 3rd May 1886, when the party returned to recess quarters at Naini Tal.

Personnel.

Lieutenant-Colonel S. H. Cowan, S. C., Deputy Superintendent, 4th grade in charge.
Lieutenant H. M. Jackson, R. E., Assistant-Superintendent, 1st grade., transferred to Mysore on 7th March 1886.
Mr. H. T. Hanby, Surveyor, 3rd grade.
" W. J. O'Sullivan, Surveyor, 3rd grade.
" W. C. Price, do. do.
" L. F. Berkeley, Asst. Surveyor, 2nd grade.
" R. F. Warwick, do. do.
" W. E. Johnson, do. 3rd grade.
19 Sub-surveyors and others.

Temporary Establishment.

348 Field surveyors and others.

148. The cadastral survey and village papers of Tahsil Harraiya and part of Tahsil Basti were completed last year; this year, the Basti Tahsil was finished, and the Khalílabad Tahsil so far advanced that only 4 *Tappas* of Pargana Maghar East, remain to be taken up next season. A survey has also been made on the 4-inch scale of the river-side villages in District Fyzabad, lying along the right bank of the River Ghagra (Gogra) opposite Parganas Mahuli West, and Mahuli East, of District Basti. The boundaries of these villages after survey were compared with the boundaries of the Fyzabad District Survey of 1862, and all discrepancies were submitted to the Deputy Commissioner for orders.

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* Colonel Hutchinson writes of the very valuable assistance and support he received from Mr. F. W. Kelly, Assistant Superintendent, who continued at work throughout the recess though much weakened by severe illness. Mr. Kelly has been obliged to take sick leave at the end of the recess and Colonel Hutchinson much regrets his temporary absence. Mr. Littlewood is reported to have maintained his high reputation of former seasons and to have managed the portion of the establishment placed under his charge most successfully. Mr. Jarbo's energy and diligence in the management of the traversing section is much praised; and Mr. Swiney's services both in field and office are said to deserve high commendation.

149. The following table shows the areas which have been surveyed cadastrally and *mauzawar* :—

District.	Pargana.	Description and scale of survey.	Number of villages.	Area in square miles.
Basti	Maghar West .	Cadastral, 16″=1 mile . .	378	112·30
	Mahuli West .	Do. . .	506	173·52
	Mahuli East .	Do. . .	601	216·64
	Maghar East .	Do. . .	787	279·33
	Rasúlpur . .	Do. . . 32″=1 mile .	2	·63
	Bánsi East .	Do. . . 32″=1 mile .	2	·62
		Total of Cadastral Survey . .	2,276	783·04
Fyzabad . . .	. . .	Mauzawar, 4″=1 mile . . .	48	36·34
		Total out-turn .	2,324	819·38

In the cadastral area, 11,26,230 fields have been surveyed, giving an average area for each field of ·445 acre. Traversing of village boundaries has been extended in advance over an area of 695 square miles, divided into 1,802 villages. Considerable delay was occasioned by the enormous number of boundary disputes, of which 625 remained unsettled on 1st March, and much anxiety was felt concerning the completion of the village papers; but the boundaries were at last adjusted through the appointment of additional Deputy Collectors, and the papers of all the villages were finished by the end of the recess.

150. The field survey has been tested by 2,216 miles of check survey, of which 345 were measured and compared with the field surveyors' maps by European officers, and 1,871 by native inspectors. To confine the angular error of the traverses, azimuth observations were taken at 28 stations, at an average distance apart of 9½ miles on the main circuits. The traverses have been connected with four principal stations of the Great Trigonometrical Survey, and the average error of the Revenue Survey chaining is found to be — 3·15 feet per mile. The names of proprietor and cultivator, details of irrigation, crops, soil, rent, &c., were tested in the *khasra* entries of 3,10,941 fields (27,607 by European officers and 2,83,334 by native inspectors).

151. Theodolite stations to the number of 4,751 have been marked by stone prisms (2½ feet long with 5-inch sides and 1 inch of the top dressed to a triangle having 4-inch sides) giving an average of 6·3 stones per square mile. The total cost has been ₹3,763, of which about ₹1,000 will be recovered from *zamindars*, leaving the remaining cost at the rate of ₹3-11-3 per square mile.

152. The area cadastrally surveyed has been mapped on 1,602 sheets, imperial size, suitable for reproduction by photo-zincography. The 4-inch work on the Fyzabad side of the Gogra, with a line of villages on the other bank entered by reduction from the cadastral 16-inch maps, has been mapped on ten sheets. The compilation of the topographical maps of the Basti District, on the 2-inch scale, for reduction by photography and publication on the 1-inch scale, has been commenced, and 9 sections or quarter sheets have been partially drawn. The 1-inch map of the whole district will probably occupy 31 of these quarter sheets.

153. The rate per square mile for the complete work of survey proper is ₹109-12-1, which includes—

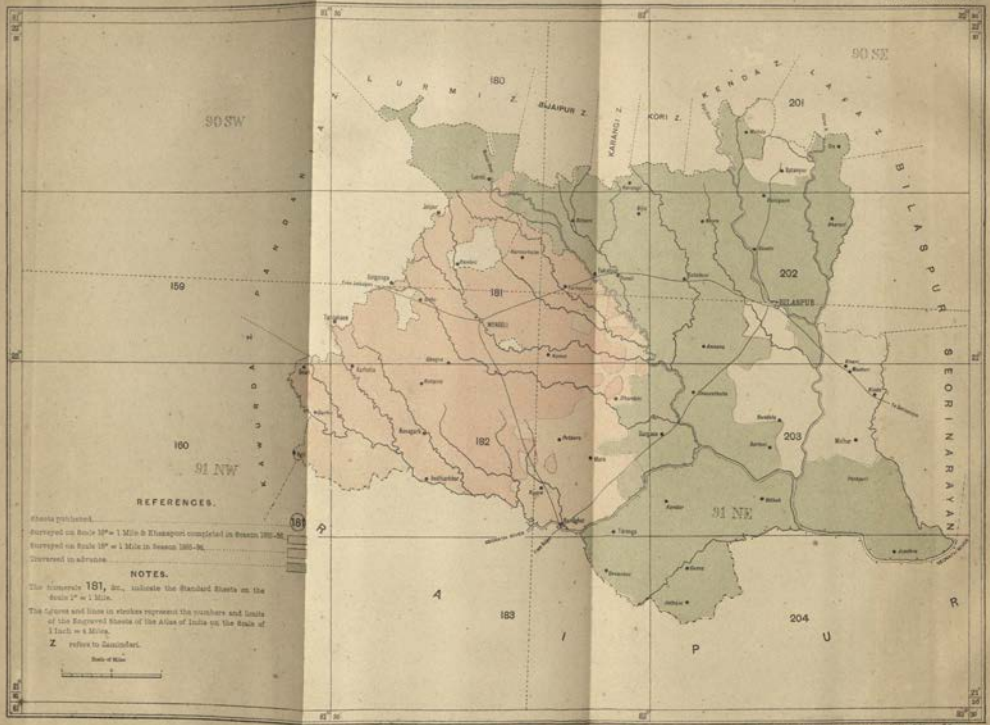
	₹	a.	p.
For permanent marks	3	11	3
„ traversing	22	10	0
„ detail survey	83	6	10

The writing of the record of rights with Urdu *khasra* complete with areas, &c. has cost ₹31,714 or ₹2-13-1 per 100 fields; and the statistics have cost ₹36,787 or ₹3-4-3 per 100 fields; or calculating per square mile (which

CENTRAL PROVINCES SURVEY.

INDEX TO THE SURVEY OPERATIONS IN DISTRICT BILASPUR.

No. 2 REV. PARTY.



Photozincographed at the Survey of India Office, Calcutta.

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Survey of India Office, Calcutta, October 1886.

however gives no fair idea of the cost of compilations which depends on the extent of the sub-division of properties), the rates are :—

	R.	a.	p.
For record of rights	40	8	0
" statistics	46	15	8

154. Three junior officers of the Civil Service, Mr. House, Mr. Bower, and Koer Jwala Parshad, were attached to the party for two months under the orders of the Government, North-West Provinces, for instruction in surveying, and are reported to have attained a sufficient knowledge of the various processes.

155. The area remaining for cadastral survey in District Basti is about 1,257 square miles, of which about 732 square miles, containing an estimated number of 15 lakhs of fields, are expected to be surveyed next field season. For traverse survey, the area remaining is only 558 miles; this will be completed in the next season, and it will be necessary that another district should be assigned to this party before October 1887.

156. Colonel Cowan reports that the Settlement Officer, Mr. Hooper, is most energetic in assisting the progress of the survey, and the Deputy Collectors under him and others of his establishment also further the work in every way they can.

157. The maps and records of the Benares District are now fully completed and some final statistics relating to that district are given in the appendix, page xiii.

158. The recess office of the party was inspected by the Deputy Surveyor General at Naini Tal during October, and was found to retain its old reputation excellent organization. This party has to be kept at a greater strength than any other cadastral party on account of the very large number of fields to be surveyed in Basti; and great credit is due to Colonel Cowan for the efficient manner in which the large establishment is supervised.*

BILASPUR DISTRICT, CENTRAL PROVINCES.

(No. 2 Party, Revenue Branch.)

159. This party, which had formerly been employed on cadastral surveys in Burma, but latterly on a topographical survey in the Shwegyin District of Burma, was transferred to the Central Provinces for the cadastral survey of the Biláspur District, in accordance with the orders of the Government of India conveyed in Revenue and Agricultural Department letter No. $\frac{57}{30-3}$ S., dated 10th February 1885, to the Chief Commissioner of the Central Provinces. The traversing section of the party was first brought up from Burma and sent on, slightly strengthened, to Biláspur, where it commenced work on 15th October. The permanent members of the party who were to be employed with the cadastral sections were brought up later, and they, also with some additions, reached Biláspur on 20th November. The temporary members of the cadastral sections, consisting of 20 *munsarims* and 200 *amins*, were enter-

Personnel.

Mr. E. J. Jackson, Officiating Deputy Superintendent, 4th grade, in charge up to 3rd November 1885.
Lieutenant-Colonel E. H. Steel, S. C., Officiating Deputy Superintendent, 3rd grade, in charge from 4th November 1885.
Mr. G. B. Scott, Officiating Assistant Superintendent, 1st grade.
Mr. F. Grant, Surveyor, 1st grade.
" H. Dowman, Surveyor, 3rd grade, up to 31st October 1885.
" A. Christie, Surveyor, 3rd grade, from 1st November to 31st December 1885.
" J. R. Scott, Assistant Surveyor, 1st grade, from 1st January 1886.
" J. McHatton, Assistant Surveyor, 1st grade.
" G. E. Parker, Assistant Surveyor, 2nd grade, up to 31st October 1885.
" P. A. Peters, Assistant Surveyor, 2nd grade, up to 29th October 1885.
" P. C. H. Smart, Assistant Surveyor, 2nd grade.
" F. W. Moore, Assistant Surveyor, 3rd grade.
25 Sub-surveyors and others.

* Colonel Cowan highly commends the good services of Messrs. Hanby and Price, who had charge of the two cadastral camps, and of Mr. O'Sullivan, who remained during the recess at Fyzabad in charge of the Statistics office.

The other assistants are reported on as follows:—"Mr. Berkeley has been in charge of the traverse camp since the beginning of March: he is a very capable and willing assistant. Mr. Warwick deserves great commendation for the readiness with which he has taken to cadastral work: he has done useful service both in field and recess." "Mr. W. E. Johnson now knows the office work of both traverse and cadastral camps very well, and he has worked diligently."

The following members of the permanent native establishment are said to have done excellent service, *viz.*, English writer Ibu Hosan, Draftsman Meer Asjad Ali, Computers Lal Mohon Gangopadhia, Sew Narain, and Kanaya Lall, and the following are well reported on, *viz.*, Sub-surveyors Inayet-oolla, Munli Manohar, Tola Ram, Bhawani Pershad and Patandin and Computer Pooran.

Of the temporary establishment, Mr. A. D. Lancaster, Supervisor, is said to have rendered most valuable service both in field and office, and the following Inspectors are said to have worked hard and showed themselves able and trustworthy, *viz.*:—Gunga Persnad, Kalim Rai, Boldeo Sahai and Madho Ram.

tained in the North-West Provinces, and were collected in the Bilâspur District on 5th December, by which date boundary plots had been got ready for them by the traversing section. The party remained in the field until the end of April 1886, when the heat having become excessive, rendering further field operations impracticable, the field establishments were discharged and the office establishments were taken to Mussooree for recess.

160. Besides the cadastral survey of the fields, the party was required, in accordance with the specification of the Chief Commissioner in letter No. 11S., dated 13th January 1885, to Secretary to the Government of India, Revenue and Agricultural Department, to undertake the writing of the village papers in preparation for a new settlement, on the system which had been adopted for the Basti and Gorakhpur Districts of the North-West Provinces. This part of the work, usually called "*Khanapuri*," was entirely new to all members of the party except to Colonel Steel himself and to a few of the *munsarims* who had been sent for a short time to the Gorakhpur Survey to acquire an insight into the procedure. Colonel Steel had therefore to set to work to teach the *khanapuri* to his European officers and to the field-surveying *amins*. He found it advisable to teach only a certain number of the *amins*, as all were not acquainted with Hindi, in which character the village papers had to be written, besides, the number of the *patwaris* was limited, one of whom had to accompany the *amins* when the *khanapuri* was being taken. About two-thirds of the *amins* were therefore employed on field surveying, and one-third, taking up the completed field maps, were employed on *khanapuri*.

161. On this part of the work, Colonel Steel reports thus:—

"With regard to the detail of *khasra* writing, I have the following remarks to make: *Firstly*, the only trustworthy documents which have been completed in the Bilâspur District by the *patwaris* during the past 17 years are the *jamábandis* of 1868 and 1882-83. In the 1868 *jamábandi*, the *sir* land was recorded with greater truth and accuracy than in the *khaleoni* of 1867, where, from motives of self-interest, it was generally overstated. In 1882-83 an inquiry was made into suits which was conducted under the supervision of Mr. Purshotum Doss. The inquiry, as far as the employment of such a staff of *patwaris* would admit, was excellent. As a rule, the rest of the records are not worth the paper on which they are written. In any village, I invariably enquired for the year in which the *patwari* visited the place. He had probably been three or four times since last settlement, but on enquiry if he had ever been into the fields, the answer was invariably 'No.' In fact, he wrote, *i.e.*, copied out, the old papers in the village, with certain fancy additions. In writing the *khanapuri*, therefore, as the *patwari* papers were of no value, some method had to be devised of finding out the tenures of new tenants since the last settlement. When the first *khanapuri* writing commenced, we tried to ascertain the tenures by enquiry in the field from the tenant and *malguzar:* we were led to believe from the perusal of the little Raipur book, that these guileless souls would agree in stating the truth. The absolute opposite was the fact. Where the *malguzar* was present, there was a wrangle over every field; where he was absent and a *thikadar* present, he might wrangle or he might not: where there was an agent, his mind, as far as tenure was concerned, was generally a blank. After much thought and discussion with Mr. Purshotum Doss, I devised the "*Fard Takikat*" or list of enquiries, indirect enquiries, into every man's tenure; its use is explained at length in the printed *khasra* procedure: suffice it to say here all difficulties vanished; the naked truth, regarding tenures and possession of *sir*, became apparent, and the work progressed. The battle of *khasra* writing in the Central Provinces was won. The *amin*, on coming into any field, was able to say, 'whose field is this,' and on referring to his 'list of enquiries' could add 'you have cultivated this field ten years, this field before that was so and so's field, and you are *mamuli*.' If it were *sir* land to the *malguzar* or to his agent he could say, 'You got this from so and so eleven years ago, as yet you are only *Khudkasht*.' The soils gave much trouble, not so much in distinguishing them as in classifying them, under the heads laid down. These are:—

Kanhar—Black cotton soil.
Dorsa—Mixed rice and cotton soil.
Matasi—Rice soil.
Kachhar—Sandy loam, on brink of rivers.
Bhata—Red stony plain.

Now, locally there is a poor *Kanhar*, called '*Gurri*,' reddish-orange, and full of nodules of *Kanhar;* also, a hard stony soil, on which short, poor, thin grass grows, which is neither *Gurri*, *Dorsa*, nor yet *Bhata*. These were difficult to place. In writing the *khanapuri*, besides tenants endeavouring to gain right of occupancy to which they were not entitled, we had to guard against false entries of soil, concealment of rents, and the suppression of the fact of the existence of sub-tenants. Besides this, the *malguzar* constantly struggled to call all *Khudkasht, Sir*."

The above extract shows the nature of the work that had to be done and the spirit in which it was undertaken. Colonel Steel found his European officers most ready learners of the *khanapuri* duties and most willing workers. In one of his progress reports he states that he and his officers "were in the villages during the whole month checking *khasra* entries. Great attention was paid to this point. The check consists in visiting nearly every *sir* and *khudkasht* field; checking soils and crop entries on the spot; ascertaining if the status of the tenants has been properly recorded; and lastly, ascertaining, as far as possible, that the rents paid by the tenants are rightly recorded."

162. A small hand-book of "Instructions concerning the preparation of the village papers in connection with the Cadastral Survey of District Bilâspur" has been drawn up by Colonel Steel, embodying the orders he issued to his establishment from time to time during the season as the work progressed. It has been printed, and it is expected will enable the *khanapuri* to be continued during next season very methodically.

163. Besides the check of the *khanapuri* entries, the check of the field map was carried out rigorously, the European officers having measured 397 linear miles of check survey and the *munsarims* 1,127 miles.

164. The area surveyed, lying entirely within the Mungeli Tahsil and included in 751 villages, amounts to 763·03 square miles of field survey, of which the *khanapuri* has been finished of 649 villages in area amounting to 605·69 square miles. Of village boundary traverse survey, the whole area which has been done is 1,795 square miles, a provision of 1,032 square miles of advance traverse work having thus been made for next field season. The number of fields surveyed is 474,296, giving an average area per field of 1·03 acres.

165. The total expenditure in field and office up to 30th September 1886, the end of the survey year, has been R1,34,940, from which the following cost rates per square mile are obtainable, after apportionment of the details of the expenditure to the several parts of the work, *viz* :—

	R	*a.*	*p.*
(1) Traversing . . . . . (Which includes the plotting of the skeleton traverse sheets.)	16	2	3
(2) Marking Stations	1	8	9
(3) Detail survey . . . . . (Which includes the fair drawing of the original maps and copies, also calculation of areas of fields.)	70	2	3
(4) Khanapuri . . . . . (Which includes the completion of the original vernacular records.)	81	15	5
TOTAL .	169	12	8

166. The above results have been obtained during the first season in a new district and in an entirely new province by an establishment which had to be largely remodelled and to be instructed in a procedure with which they had hitherto been unacquainted, having also to learn the law of their new province and to some extent its language; and it is confidently expected that much lower rates will be exhibited as the result of next season's working. For the present season even more favorable rates than those quoted above might very reasonably be claimed by the exclusion from the total expenditure of a certain share of R6,783, the cost of a new equipment of tents, also of parts of the expenditure of R16,200 incurred in transporting the party to Bilâspur and in salaries during October and November, while only traverse work was being done; likewise of part of the expenditure of R12,900 during December, when the cadastral survey was only ten days in actual progress; but the proper sums to be excluded are difficult of calculation, and, as expenditure of the nature referred to has generally to be incurred when a survey party is removed from a distant locality and at the same time remodelled for new operations, no attempt has been made to arrive at estimated rates by an estimated reduction of the expenditure.

167. The Administration of the Central Provinces have decided not to have the cadastral maps of Bilâspur printed, as two copies on tracing cloth will

suffice for all requirements. These copies have been prepared and are ready to be sent to the Settlement Officer. Besides the original copies of the village papers, which consist of—

Khasra Jamabandi		Milan Khasra Jinswara

Jamabandi Abstract,

the Administration require copies of these to be prepared, but the requisition was not received in time to admit of the papers of more than 100 villages being copied during the recess.

168. The recess office of the party was inspected at Mussooree during September by the Deputy Surveyor-General in charge of the Revenue Branch, who expresses himself highly satisfied with the state of the records, and who desires to bring to notice the intelligent and energetic manner in which Colonel Steel has undertaken the introduction of the system of record-writing, combined with a cadastral survey, into the Central Provinces, and the high state of efficiency to which he has brought the members of his establishment by his own personal exertions in training them.*

GORAKHPUR DISTRICT, NORTH-WEST PROVINCES.

(No. 5 Party, Revenue Branch.)

169. This party, which has continued throughout the year under the charge of Major J. E. Sandeman, returned from recess quarters at Naini Tal to resume field operations in District Gorakhpur on 15th October 1885, and remained in the field until 10th April 1886. Mr. E. Little, Surveyor, was then left in an office at Gorakhpur with a suitable establishment to prepare the statistical tables and Hindi records; and the rest of the party, with establishment, proceeded to recess at Naini-Tal for the completion of the maps, the traverse computations, the area computations and the Urdu *khasras*.

Personnel.

Major J. E. Sandeman, S.C., Officiating Deputy Superintendent, 2nd grade, in charge.
Captain R. A. Wahab, R.E., Officiating Deputy Superintendent, 4th grade, from 8th November 1885 to 10th April 1886.
Mr. E. G. Little, Surveyor, 3rd grade.
„ T. F. Freeman, Asst. Surveyor, 1st grade.
Mr. J. Murphy, ditto ditto.
„ A. W. Smart, ditto ditto.
„ N. Bedford, ditto 3rd grade.
„ W. V. Skilling, ditto ditto.
17 Sub-surveyors and others.

Temporary Establishment.

540 Field surveyors and others.

170. With the exception of a strip of overlap topographical survey beyond the district boundary in the Sarun District of Bengal, the work has been a cadastral survey on the 16-inch scale, combined with the writing of the village papers, such as have been described in previous Reports. A few changes in procedure have however been introduced, of which the following are the most important:— *1st*—Village boundaries have been surveyed along with the skeleton traverse instead of being left to be surveyed separately for each village with the fields. This is believed to have had the effect of reducing the number of boundary disputes: there having been fewer disputes this year than during the previous year. *2nd*—The *jamábandi* in Urdu is now prepared in the Survey office instead of in the offices of Deputy Collectors. This has not raised the survey rates, and is believed to have saved the expenditure of large sums in the Settlement office. *3rd*—Alluvial *Mahâls* are now demarcated at time of survey, which has

* Colonel Steel, mentioning the names of Mr. G. B. Scott, Messrs. F. Grant, J. McHatton, J. R. Scott, P. C. H. Smart, and F. W. Moore, writes as follows:—

"I have never been associated with a better set of officers, whether it be on account of their general knowledge, their work, or the willing spirit in which they have always carried out my slightest suggestions. Their hearty agreement among themselves, strong sense of mutual reliance and devotion to their duty during a peculiarly trying year has won my esteem and respect."

The name of Mr. G. H. Kineley, writer, and the names of computers Reedoy Chunder Doss and Makkan Lall Singh are also mentioned by Colonel Steel, on account of the excellent work they have done.

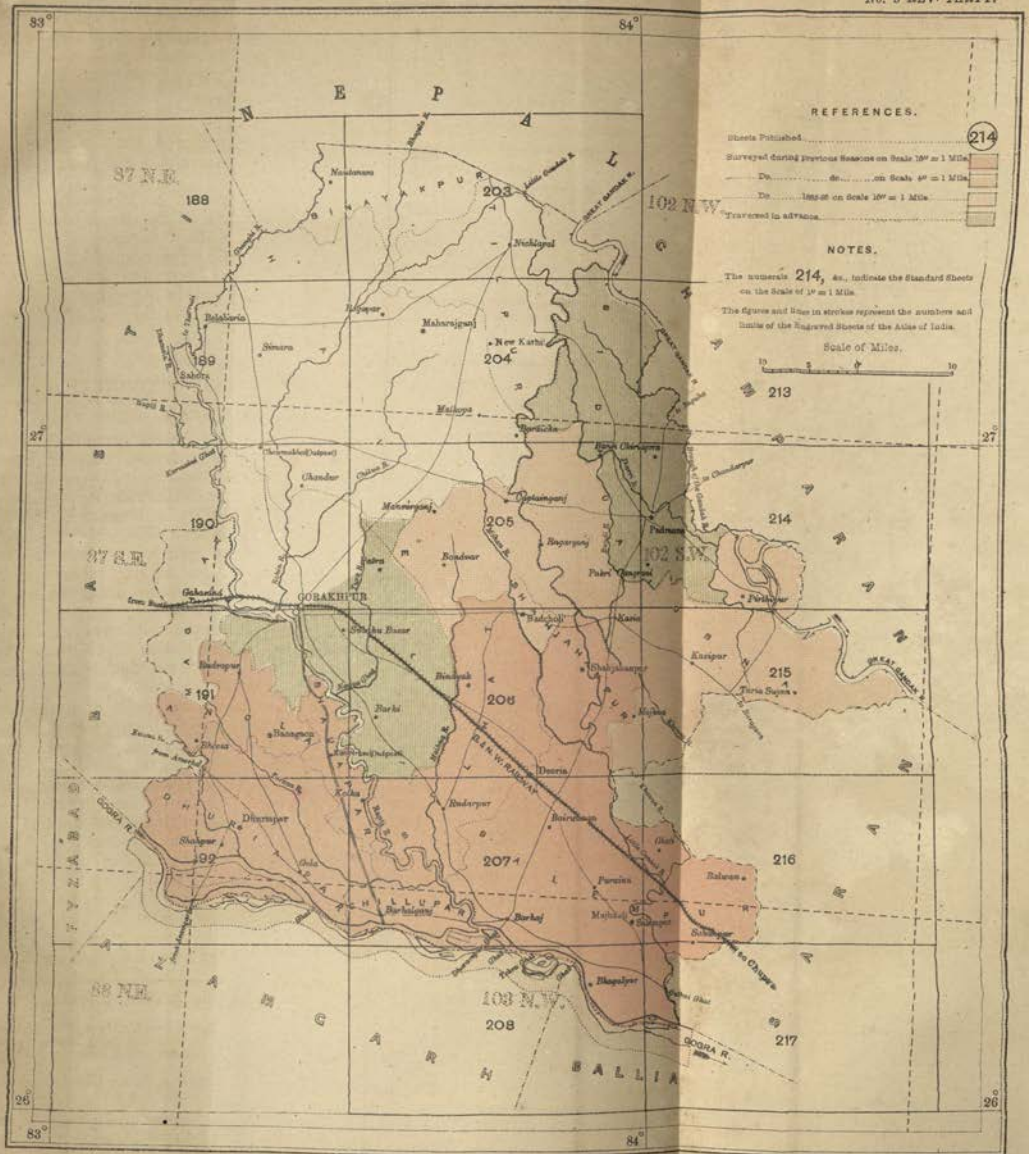
Finally, Colonel Steel reports as follows:—

"I cannot conclude this report without recording the services rendered by my friend and Civil Assistant, Mr. Purshotum Doss, Assistant Settlement Officer. He had a most intimate knowledge of the people, their customs, and everything connected with the district. He is a man of extended knowledge, excellent ability, and untiring energy. I can only say that he identified himself with our work and placed his best services at my disposal. That there was no friction between the Survey and the country people, is mainly due to his excellent management, and I conclude by saying that my warmest thanks are due to him for his courtesy and ever ready assistance.

N. W. PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTRICT GORAKHPUR.

No. 5 REV. PARTY.



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Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., Officiating Surveyor General of India,
Survey of India Offices, Calcutta, November 1886.

enabled separate *jamabandis* to be prepared of the portions of villages which come under quinquennial settlement. *4th*—The preparation of Hindi copies of the *khasras* at time of survey by the *patwaris* has been discontinued. *5th*—The classification of natural soils has been modified, the fields having been recorded under the three classes—of "table land," "slope," and "low land;" instead of being distinguished as formerly as—"clay," "loam," or "sand." *6th*—The conventional soil zones of "home-lands," "middle" and "out-lying" tracts are no longer marked on the original survey maps. *7th*—The typing of English names on the maps has been reduced and greater prominence has been given to the names in the vernacular. Under directions from the Board of Revenue the definition of a "field" has been altered in the Hand-Book of Instructions and now stands as follows:—

"A field is a parcel of land lying in one spot in the occupation of one cultivator, held under one title, and generally known by some name in the village."

171. Major Sandeman continues to advocate the transfer of the "fairing" of the village papers from the Settlement office to the Survey office, where he believes the work could be done very much more economically through the supervision of the European officers. He understands that this work at present costs R60 or R70 per square mile, which, as he points out, is more than the expenditure on the original papers.

172. The areas of completed survey with records by *tahsils* are shown in the following statement:—

District.	Tahsil.	Description and scale of survey.	Number of villages.	Area in square miles.
Gorakhpur	Hata	Cadastral, 16-inch to a mile.	457	275·38
	Parauna		794	544·71
Total Cadastral Survey	...	...	1,251	820·09
Sarun (Bengal) . . .	...	Topographical, 2-inch.	...	41·07

In addition to the above, preliminary boundary traversing has been executed for 394 square miles of the Parauna Tahsil and for 346 square miles of the Gorakhpur Tahsil. The cadastral area includes 894,028 fields, of which the average size is ·58 of an acre.

173. All theodolite stations have been marked either with stones or burnt clay cylinders. Stones are used for all stations placed on the sites of village boundary marks and for stations at half-mile intervals along streams where the traverse stations are off the actual boundary. For other stations off the boundary and for stations in the interior of villages, cylinders are used. The number of stations so marked are 7,756 with stones, and 2,856 with cylinders, besides which, there are the village tri-junctions permanently marked by the Settlement authorities at the time of the village boundary demarcation.

174. Observations for azimuth to check the angular work of the traverse survey have been taken at 78 stations. The traverses have been connected with 6 stations of the Great Trigonometrical Survey and the triangulation co-ordinates have been used for correcting the distances of the measured traverses. In two cases of comparison with the triangulation, the error of the measured distances is *plus*, averaging ·9 feet per mile, and in eight cases the errors are *minus*, averaging 2·03 feet per mile. The surveys to check the cadastral plotting, executed partly by Assistant Surveyors and partly by native inspectors or *munsarims*, amount to 1,712 linear miles, on comparison with which the work is said to have been found to be very good. The *khanapuri* was also subjected to the usual amount of check. The Assistant Surveyors and four head inspectors,

in addition to the inspectors over squads of *amins*, were constantly moving about, checking the work, and the returns show that 19,786 fields were tested by Assistant Surveyors and 133,176 by inspectors, or 17 per cent. of the whole.

175. There are 15 unsettled disputes on the boundary of the Sarun District of Bengal common with the Parauna Tahsil, maps of which have been prepared showing the demarcated boundaries as well as the boundary lines taken from the maps of 1837, and forwarded to the Settlement Officer. The decisions in the cases of dispute on the same boundary common with the Deoria Tahsil have been appealed against by the Sarun *zamindars*. A new boundary has been demarcated between Districts Gorakhpur and Azamgarh where the Gogra River, owing to a change in its course, had ceased to be the boundary.

176. The cadastral area has been mapped on 1,447 sheets. These will be retained in the office of the party pending the Settlement attestation of the village records, on completion of which they will be sent down in batches to Calcutta to be printed. The series of sheets on the 4-inch scale, numbering 23, of the *diwara* of the Gogra River, mentioned at paragraph 224 of last Report, has been completed. On these, the boundaries of all submerged villages, in which rights are at present dormant, have been traced from the maps of 1837, so that, if the river again changes its course, and claims for the lands in question are made, the maps are ready for relaying the boundaries. The traverse projections of the 2-inch maps of the Gorakhpur District are being done in the party office and the drawing of the topography by reduction from the 16-inch maps will be done in the Surveyor General's Office.

177. Regarding the cost of the operations, Major Sandeman reports :—

The out-turn and rates compare well with those of the two former seasons, although there is only a slight fall on last year's rates. The old form appearing obsolete, I have filled up the one which was adopted for the half-yearly return. The cost of the 16-inch field survey has been separated from that for extraction of areas and finishing up of maps, and the cost of *khanapuri* has been separated from the cost of completion of the Urdu *khasras*. Thus, it can be seen in both cases how much the field work and how much the office work cost separately.

The rates per square mile during the past three seasons are as follow :—

	1885-86,	1884-85.	1883-84.
	R a. p.	R a. p.	R a. p.
(1) Stone embedding	10 4 5	26 9 1	30 8 5
(2) Traversing	20 7 11		
	30 12 4		
(3) 16-inch field survey	44 15 1		
(4) Khanapuri (record of rights)	21 3 1	100 11 1	110 7 5
(5) Areas (extraction of) and completion of maps	25 9 6		
(6) Completion of Urdu records	9 5 9		
	101 1 5		
(7) Hindi records, statistics and soils	38 7 11	43 13 10	36 13 5
	170 5 8	171 2 0	177 13 3

The rates for the current season include the cost of the preparation of the *jamá-bandis* which were prepared by the Deputy Collectors formerly, so that the rates compare more favorably than would at first appear. This has moreover saved a large expenditure in the Settlement office.

178. Messrs. Winter, Cobb and Lovett, of the Civil Service, were attached to the party during January and February 1886, and were instructed in several systems of surveying.

179. The Senior Member of the Board of Revenue, North-West Provinces, inspected the work in the field on the 25th and 26th January, and the Director of Agriculture likewise visited the party on 23rd and 24th March.

180. Major Sandeman writes as follows regarding the Civil Officers with whom he has been associated :—

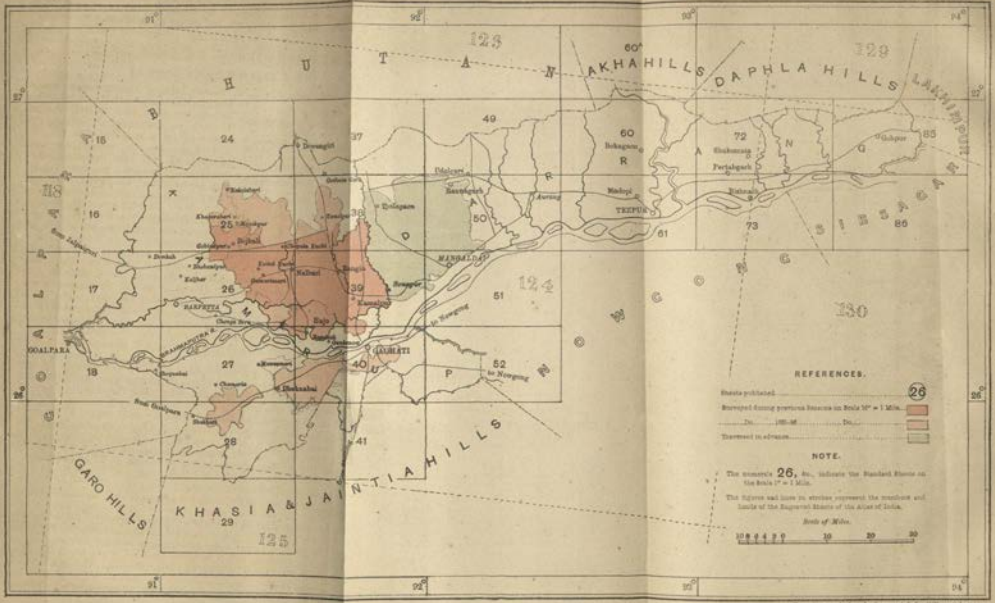
"Again, I have to thank the Settlement Officer, Mr. J. D. LaTouche, for all the aid he has given us; also the Collector of the District, Mr. Mellor, and the Deputy Collectors of Settlement for their co-operation."

181. The recess office of the party was inspected at Naini Tal during October by the Deputy Surveyor General in charge of the Revenue Branch, who expresses himself highly satisfied with Major Sandeman's government of his

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTRICTS KAMRUP & DARRANG.

No. 6 REV. PARTY.



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Survey of India Office, Calcutta, October 1896.

Photolithographed at the Survey of India Offices, Calcutta.

large establishments, the efficiency of which is amply testified by the character of the records and the regularity with which all the work is conducted. Major Sandeman continues his unceasing endeavours to adopt any changes in procedure which may seem likely to conduce to economical working and to more effective collaboration of the Settlement and Survey establishments.*

KAMRUP AND DARRANG DISTRICTS, ASSAM.

(No. 6 Party, Revenue Branch.)

182. This party under Mr. E. C. Barrett resumed cadastral operations in District Kámrúp on 10th November 1885; and at the same time entered District Darrang to undertake the preliminary traversing for a cadastral survey there. Field operations were brought to a close on the 10th May 1886, when the office establishment returned to recess quarters at Shillong. The party continued under Mr. Barrett up to the 4th July; when, on Mr. Barrett's proceeding on three months' privilege leave, Mr. J. H. O'Donel, the senior Surveyor, was placed in temporary charge.

Personnel.

Mr. E. C. Barrett, Officiating Deputy Superintendent, 3rd grade, in charge.
„ J. H. O'Donel, Surveyor, 4th grade, in temporary charge, from 5th July to 4th October 1886.
Mr. D. A. King, Surveyor, 4th grade.
„ J. Connor, Surveyor, 4th grade.
„ J. C. Kelly, Assistant Surveyor, 2nd grade, up to 30th June 1886.
„ J. Smith, Assistant Surveyor, 3rd grade.
24 Sub-surveyors and others.

Temporary Establishment.

298 Field surveyors and others.

183. The nature of the cadastral operations has been the same as during the past two seasons, *viz.*, a 16-inch field survey combined with the writing of a *khasra*. These operations have been carried on in the Kámrúp District, partly in the Gauháti Sub-Division to the south of the Brahmaputra, and partly in the Barpetá Sub-Division to the north of the river. The tracts surveyed in both sub-divisions, cover a total area of 468·18 square miles, which, as will be seen by a reference to paragraph 236 of last Report, is considerably in excess of the area expected to be surveyed under a reduced budget grant. The total number of fields in both tracts is 147,818 of an average size of 2·03 acres.

184. The cadastral survey now completed on the 16-inch scale in District Kámrúp is contained in four separate blocks of villages lying two to the north and two to the south of the Brahmaputra River, and covers a total area of 1,174·39 square miles. The total number of fields surveyed and registered is 583,426, and the average size of the field over all is 1·29 acres. All the large tracts of country under permanent cultivation in District Kámrúp have been surveyed in these four blocks of villages, and it is not contemplated to extend the survey to *jaringhati mouzahs*, where the cultivation is chiefly fluctuating, and where the cost of keeping up the survey records would consequently be great. The cadastral survey has therefore been finished in Kámrúp, and next year it will be carried on in District Darrang.

185. Preliminary traverse operations have been confined to the Mangaldai Sub-Division of District Darrang, where an area of 474·32 square miles has been surveyed in preparation for next year's cadastral survey. In Darrang, the unit known as the village did not exist prior to the commencement of these operations. The smallest of the main sub-divisions was the *mouzah*, and as *mouzahs* cover areas varying from 5 to 30 square miles, it was found necessary to sub-divide them into village blocks of convenient size. The new villages

* Regarding the services of the officers serving under him, Major Sandeman writes in the following terms:—

"Captain Wahab, R.E., while in charge of the traverse camp, gave me his cordial co-operation for which I am much indebted to him. Messrs. Little and Freeman, in charge of the detail camps, have once more given proof of their capacity to manage large survey camps successfully and supervise the preparation of the village records as well as the survey. They, as well as their assistants, Messrs. Murphy and Bedford, have worked most laboriously, and it has been with the utmost satisfaction that I have seen the special allowances which were recommended for them sanctioned by Her Majesty's Secretary of State. Mr. A. W. Smart succeeded Captain Wahab, in charge of the traverse camp, and I have every reason to be satisfied with the manner in which he has superintended the work. Mr. Skilling has done well and is a promising assistant. In the native establishments, the following are deserving of special mention, *viz.*, *Permanent Establishment.*—Puran Chand, Nidha Lal, Joala Pershad, Waris Ali, Ganga Pershad, Ghulam Gaus Khan, Jairam Singh, Abdul Hadi, Lalji Mul. *Temporary Establishment.*—Abdul Hamid, Jai Narain, Hari Singh, Amanat Hosein, Bishambar Sahai, Majibulla, Ramdatt."

have been made as symmetrical as possible, and in area about 600 acres, which will admit of their being plotted on one imperial-sized sheet of paper as ordinarily used for cadastral maps.

186. The cadastral survey has been carefully checked by 1,058 linear miles of test surveys, of which 429 miles were run by European officers and 629 miles by native inspectors. The *khasra* entries of 14,395 fields have been checked by the European officers; and this work has also been independently tested by *munsarims* and Sub-Deputy Collectors of the Settlement staff.

187. Over three-fourths of the *amins* were natives of the North-West Provinces, the remainder being chiefly Bengalis, and only two being natives of the Assam Valley. The Hindustani *amins* as usual did the largest amount of work, but the Bengalis pushed them very closely and their work was quite as good as that of the Hindustanis. One of the Assamese *amins* is said to be an excellent field surveyor.

188. The triple-junctions of all villages are marked by stone prisms, 3 feet long and with 1 foot sides, which have been adopted as theodolite stations. The positions of the theodolite stations intermediate between tri-junctions are indicated by *semal* tree branches planted 5 feet north of the station points.

189. The season's out-turn has been mapped on 653 sheets, tracings of which, with the village *khasras*, were all sent to the Settlement Officer before the end of the recess.

190. The revision survey of the work of season 1884-85 was carried out by ten field parties, each consisting of a Settlement *munsarim* and a Survey *amin*, between 5th November 1885 and 24th February 1886. Out of 396 villages which came under this revision survey, 136 villages were passed without the need of any change whatever.

191. The cost rate of the combined operations of settlement and survey for season 1884-85, which was stated in paragraph 235 of last Report to be R269-13-10 per square mile, as arrived at partly from an estimated rate for revision survey, requires a slight alteration in accordance with the actual revision survey rates, as now shown in the following statement:—

Season 1884-85.

	Area.	Rates.	
	Square miles.	Per square mile.	Per acre.
		₹ a. p.	₹ a. p.
Cadastral Survey, with *khasras*	478·05	215 11 3	0 5 4
Revision Survey — Survey expenditure	...	2 8 10	0 0 1
Revision Survey — Settlement expenditure	...	12 8 9	0 0 4
Settlement	...	49 2 6	0 1 3
Combined operations	...	279 15 4	0 7 0

In the following statement for the past season, the revision survey rates are approximate:—

Season 1885-86.

	Area.	Rates.	
	Square miles.	Per square mile.	Per acre.
		₹ a. p.	₹ a. p.
Cadastral Survey, with *khasras*	468·18	199 15 6	0 4 11
Revision Survey — Survey expenditure (App.)	...	2 8 10	0 0 1
Revision Survey — Settlement expenditure (App.)	...	12 8 9	0 0 4
Settlement	...	48 5 4	0 1 3
Combined operations	...	263 6 5	0 6 7

BEHAR SURVEY.

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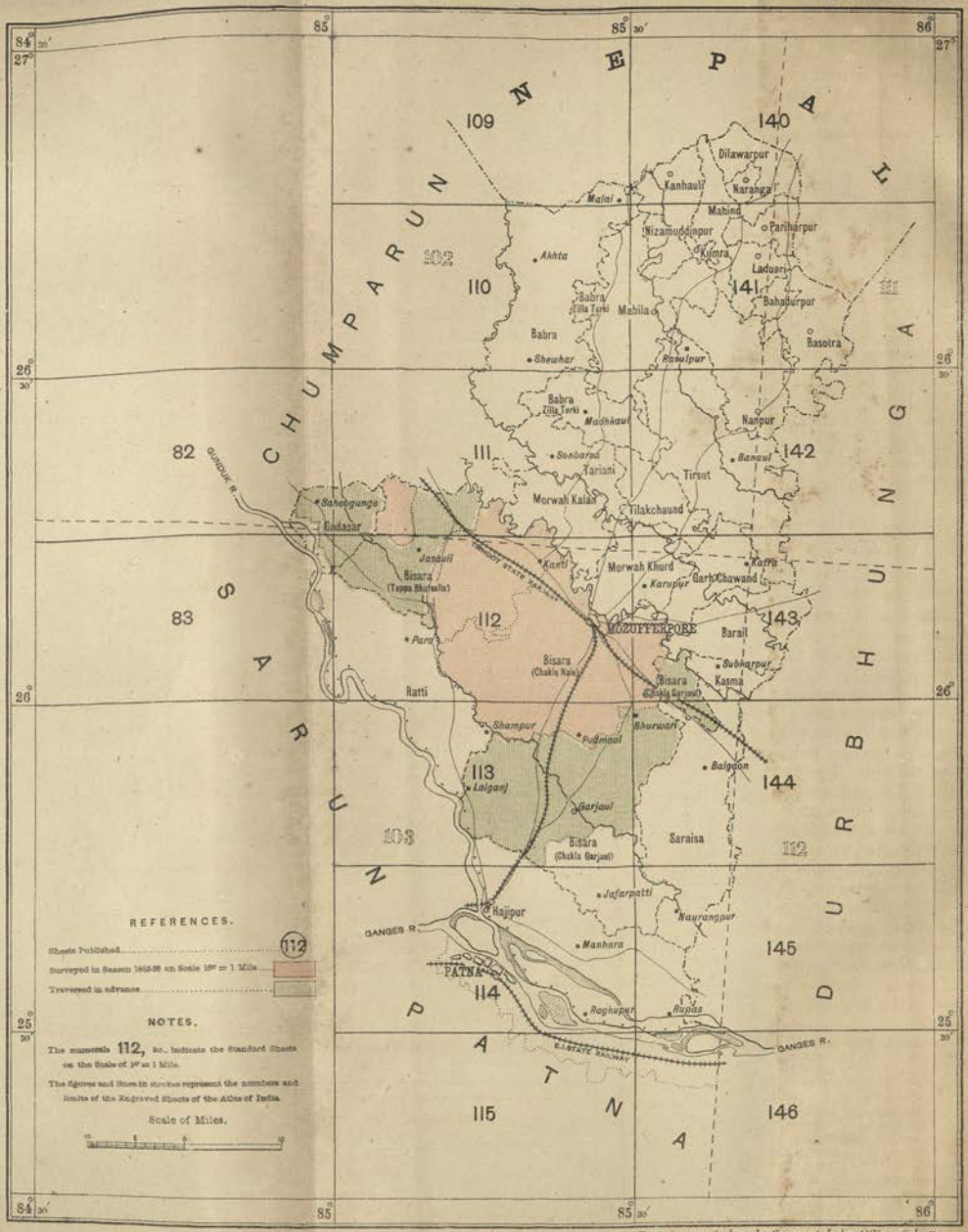
No. 8 REV. PARTY.



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Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, November 1886.

192. The Chief Commissioner of Assam, Mr. W. Ward, visited the Survey camp at Rangiya during February, when he was shown over the camp offices and the procedure adopted by the Survey was explained.

193. Mr. Barrett makes particular mention of the great assistance rendered to the party by the district officials of Kámrúp and Darrang, to whose excellent arrangements he ascribes the entire absence of all friction between the Survey establishments and the village people in either district.*

MOZUFFERPORE DISTRICT, BENGAL.

(No. 8 Party, Revenue Branch.)

194. This party was transferred from Burma to Bengal for the purpose of undertaking in the District of Mozufferpore, in Behar, under the Bengal Tenancy Act (VIII of 1885), an experimental cadastral survey with the preparation of a record of rights, which was sanctioned in letter No. 214—97-1S., dated 1st June 1885, from Secretary to Government of India, Revenue and Agricultural Department, to the Surveyor General of India. The party reached Mozufferpore on the 13th October 1885, under charge of Mr. R. B. Smart, and after having been intermediately held in charge by Mr. W. A. Wilson, the senior Surveyor, was finally made over to Lieutenant-Colonel W. Barron on 16th November 1885. Several transfers of Sub-surveyors from other parties had to be made so as to bring the permanent establishment up to proper strength for the traverse work. The temporary establishment brought from Burma formed merely a nucleus of the full strength required for the cadastral survey and had to be largely added to at Mozufferpore. The traverse survey was begun on 16th October and was closed on 15th April. The cadastral survey could not be taken in hand until the first week in December, and owing to this late date of beginning operations, the work had to be continued into the month of July. Fortunately the rains were late and the season was favourable for the men staying out, otherwise the field season could not have been so long protracted. The party recessed at Mozufferpore.

Personnel.

Lieutenant-Colonel W. Barron, S.C., Deputy Superintendent, 2nd grade, in charge, from 16th November 1885.
Mr. W. A. Wilson, Surveyor, 2nd grade, in temporary charge, from 19th October to 15th November 1885.
„ R. B. Smart, Surveyor, 4th grade, in temporary charge, to 18th October.
„ T. Shaw, Assistant Surveyor, 1st grade, from 18th January 1886.
„ E. P. S. Hill, Assistant Surveyor, 1st grade, from 13th to 28th April 1886.
„ B. R. Hughes, Assistant Surveyor, 2nd grade.
„ A. B. Smart, Assistant Surveyor, 3rd grade.
„ C. G. Lee, Assistant Surveyor, 3rd grade, from 1st March 1886.
23 Sub-surveyors and others.

Temporary Establishment.

132 Field-surveyors and others.

195. The cadastral survey was as usual done with great minuteness, every feature being represented which could be shown on the ordinary scale of 16 inches to a mile, which scale had however to be increased for the sake of greater clearness in the case of a few villages near the station of Mozufferpore to that of 24 inches to the mile. The unit of separate measurement and separate area calculation was the "field," defined as, "being the plot separately assessed to rent under existing arrangements and in occupancy of the same *raiyat*." In the village sites, the houses, which are generally scattered with small plots of land attached, have each been treated as a separate "field."

196. The chief papers which have been prepared for the record of rights are the *khasra* or general village register of all the fields, and the *khatian*, or separate register of the fields of each tenant. In both of these the record for each field

* Regarding the services of his establishment, Mr. Barrett reports as follows:—
Mr. O'Donel was in charge of a Cadastral Camp throughout the year, and in addition to his own duties held temporary charge of the party during the three months that Mr. Barrett was on leave. It need only be said of Mr. O'Donel that he has quite upheld his previous reputation in the department. Mr. King, who also supervised a cadastral camp, has given entire satisfaction. Mr. Connor worked very hard throughout the year, and has brought the computations of the traverse work well up to date. Messrs. Kelly and Smith did excellent service during the field and recess seasons. Mr. Kelly was transferred to the Forest Department on 1st July.
The following members of the professional establishment are deserving of mention for steady hard work:—Sub-surveyors Mohan Sing, Tajjuddin, Sakhawat Hossein, and Khurshed Hossein. Computers Saroda Proshad Chuckerbutty, Ganga Ram, and Janardhan Rao, and Golam Hyder Khan, Draftsman. Babu Sitanath Chuckerbutty, cadastral supervisor and head writer, has worked throughout the year with zeal and steadiness; his services are again brought to favorable notice. The following cadastral hands have also done well:—Jhunni Lall, Balbhadria, Haraknarain, and Kedarnath.

includes the names of four *raiyats* of adjoining fields, so as to describe the position of the field irrespective of the map.

197. The soil has been recorded under the headings of "*Dhanhan*" and "*Bhit*" with a distinction between first and second classes of each where such could be ascertained. The crops have been recorded under three harvests, *viz.*, "*Bhadoi*," "*Rabi*" and "*Aghani*;" and where there were mixed crops, the proportions of the different cereals sown have been estimated.

198. A system, unknown in cadastral surveys elsewhere, has been adopted of having the areas of the "fields" computed by the field surveyors (*amins*) and communicated to the *raiyats* on the spot.

199. The area in which the cadastral survey and record of rights have been completed is shown in the following statement:—

Pargana.	Tappa.	No. of villages.	No. of fields.	Area.		Remarks.
				Acres.	Square miles.	
Bisára ...	Chakla Nai	441	582,200	169,600	265	
	Bhatsala	215		95,360	149	
	TOTAL	656	582,200	264,960	414	

The above includes the whole of Tappa Chakla Nai, except 3 or 4 square miles within the Mozufferpore Municipality. Of Tappa Bhatsala, about 90 square miles are left unsurveyed. The boundary traverse survey, besides the area cadastrally surveyed, embraced the remaining part of Tappa Bhatsala, part of Tappa Chakla Garjaul of Pargana Bisára, and Pargana Gadehsar. An area of 389 square miles has thus been prepared for a continuance of the cadastral survey.

200. The survey was checked by 1,156 linear miles of test surveys, of which 327 miles were run by the European assistants and head inspectors, and 829 miles by the squad inspectors. The entries in the *khasras* were checked for 178,784 fields, of which the assistants and head inspectors checked 50,055 or 9 per cent. of all the fields, and the inspectors, 128,729 or 22 per cent. of all. For the traverse survey, observations for azimuth were taken at 75 stations and connections were made on five stations of the Great Trigonometrical Survey. By means of the latter seven comparisons were made between triangulation and traverse distances, showing that the chaining had an average error of 1·7 feet per mile.

201. The permanent demarcation of village boundaries has been done partly by the settlement establishment and partly by the surveyors. The former establishment began the work before the arrival of the Survey, and while carrying out the erection of temporary marks at all the bends of the boundaries, undertook to place stones at the tri-junctions. These stones were supplemented by the surveyors who first began by placing other stones of a smaller size at all the boundary theodolite stations; but, afterwards, the plan of marking all the stations with stones was relinquished on account of the expense, and stones were placed only at a certain number of selected stations, inexpensive pottery cylinders being substituted for them at most of the stations. The traverse surveyors overtook the settlement establishment engaged on the temporary demarcation and on fixing the tri-junction stones, and in Chakla Garjaul they surveyed the boundary traverses with the aid of the old Revenue Survey maps without previous demarcation, placing also the tri-junction stones. The village boundaries were first surveyed as pointed out by the village authorities and afterwards compared with the maps of the old Revenue Survey in accordance with which the boundaries had to be mapped. The comparisons showed that, except where there had been river action, the old boundaries had been well preserved.

202. The total expenditure on the survey from the time the party was transferred from Burma up to 30th September 1886, which is the conclusion of the survey year, was ₹1,23,566-5-9. In this, however, as reported by Colonel Barron, are included several items of expenditure that occur on the moving of a survey, from one district to another, also a charge for a new equipment that does not occur every year, and the pay of men non-employed, which may be called

loss of strength, before the survey was fairly started. These items are tabulated by Colonel Barron as follows :—

	₹
Pay prior to 15th October	2,110
Travelling allowances from Calcutta	1,488
Carriage of equipment from Burma	1,308
Cost and carriage of new tents	5,633
Loss of strength at beginning of field season	2,990
Cost of surplus mark-stones	600
Total	14,129

Deducting the above preliminary and extraordinary expenditure, the cost of the work would be reduced to ₹1,09,437-5-9 and the following tables of cost rates on the completed area of 413 square miles—(1) without deducting the extraordinary expenditure, and (2) after deducting this expenditure, are arrived at :

	Per square mile.			Per acre.			Per field.		
(1) Without deductions—	₹	a.	p.	₹	a.	p.	₹	a.	p.
Stone embedding	14	2	11	0	0	4	0	0	2
Traversing	28	13	3	0	0	9	0	0	4
Detail Survey	97	1	11	0	2	5	0	1	1
Total for Survey	140	2	1	0	3	6	0	1	7
Records (Khanapuri)	59	8	1	0	1	6	0	0	8
Completion of records and statistics, in office	69	8	7	0	1	8	0	0	9
Total for records	129	0	8	0	3	2	0	1	5
GRAND TOTAL	269	2	9	0	6	8	0	3	0
(2) With deductions—									
Stone embedding	12	3	10	0	0	3	0	0	1
Traversing	25	14	7	0	0	8	0	0	3
Detail Survey	88	3	2	0	2	2	0	1	0
Total for Survey	126	5	7	0	3	1	0	1	4
Records (Khanapuri)	53	13	2	0	1	4	0	0	7
Completion of records and statistics, in office	57	8	10	0	1	5	0	0	8
Total for records	111	6	0	0	2	9	0	1	3
GRAND TOTAL	237	11	7	0	5	10	0	2	7

203. Colonel Barron further reports as follows :—

"Several reasons have already been mentioned why the cost rates are high for this season, such as the first season in a district, the necessity of training an establishment, the short out-turn which renders the cost of superintendence greater per square mile than when spread over a larger area, &c. Others may be noted, which would always have a tendency to make the work in Behar cost more than in the North-West Provinces, *viz.*, (1) The village sites: the houses in Behar are not on one compact site, but are scattered about with cultivation between them; hence instead of being able to treat the village as one number, as is the case in the North-West Provinces, the houses and intermixed cultivation have to be treated as separate fields and each to be recorded under its own number and *patti*. (2) The records: the *khasra* and *khatiân* forms are more complicated than those in the North-West. The boundaries of the fields have to be recorded in both documents by giving the names of four *raiyats* on the four sides of the field, and the crops have to be tabulated and calculated for three harvests instead of for two. The *amins* have no *patwaris* to write the *khasras* and *khatians*, and they have besides to take out the areas of the fields on the spot for the satisfaction of the *raiyats*."

"With a well trained establishment, the extra cost of these things would be reduced to a minimum, but there would still remain the extra expenditure on labor which has all to be paid for. The *amins* had to be provided with four chain-and-flag-men instead of one or two, because they could not demand labor from the villagers. During last season, while the cost of the *amins* was ₹13,900, and their *moharrirs* ₹2,665, the cost of their chain-men was ₹16,570."

"During next field season, if work had continued in District Mozufferpore, a considerable reduction in the cost rate would have been effected. A trained establishment would have started at the beginning of the field season, and a full out-turn of 800 square miles

or more of interior survey would have been accomplished, thus reducing, per square mile, the cost of European superintendence by nearly one half, and lessening the square mileage rate under this head by about R15 to R20; also the charge for *moharrirs* would have ceased, and an endeavour would have been made to obtain some assistance from the villagers, or by paying by the day to secure cheap labor when wanted. The stones for marking stations would have been sparingly used and clay cylinders would have been substituted, thus reducing the cost of marking stations by about R10. Altogether it was considered probable that the cost for next season would have been less than 5 annas an acre or below R200 a square mile."

204. There are 734 cadastral sheets comprising the season's out-turn, of which simple manuscript tracings have been supplied to the Settlement Officer for immediate use, but the question of the printing of the sheets is still undecided. The sheets have been prepared with titles and adjoining names in the Devanagari character, the only English writing being the name of the village entered alongside of the Devanagari name in the title. General maps (on the 2-inch scale) of the area cadastrally surveyed have been projected, but the drawing still remains to be done.

205. During the field season, Messrs. Walsh and Coxe of the Civil Service were attached to the party to be instructed in surveying and in writing up the records. They each surveyed one village and superintended the writing up of its records.

206. On account of the different procedure in many matters connected with the preparation of the record of rights in Bengal from that in vogue in the North-West Provinces, the nature of the tenures being also different, Colonel Barron found the Hand-Book of Instructions which he had drawn up for the use of cadastral survey parties in the North-West Provinces to be unsuitable for Mozufferpore, and he has drawn up a new edition specially adapted for Mozufferpore, but believed to be suitable for Behar generally. The edition has been prepared both in English and in the vernacular, the latter having been printed in the Persian character.

207. Although it was known in October 1886 that the survey of Mozufferpore would be stopped, yet it was not known whether the survey of an area of about 95 square miles might not be required to complete Parganas Chakla Nai and Bhatsala, or whether the records of the part surveyed would be completed before the party left Mozufferpore. The office establishment therefore worked on during October. In the beginning of November the traversing section of the party was sent to Calcutta to begin the town survey there, but the section employed on the maps and in compiling the records were kept at work at Mozufferpore till 20th November, when final orders were received to close the survey absolutely. Part of the establishment was then paid up and discharged, and the rest transferred to Calcutta and to Sunkerpore, a ward's estate in the Dinagepore District which was opportunely made over for survey.

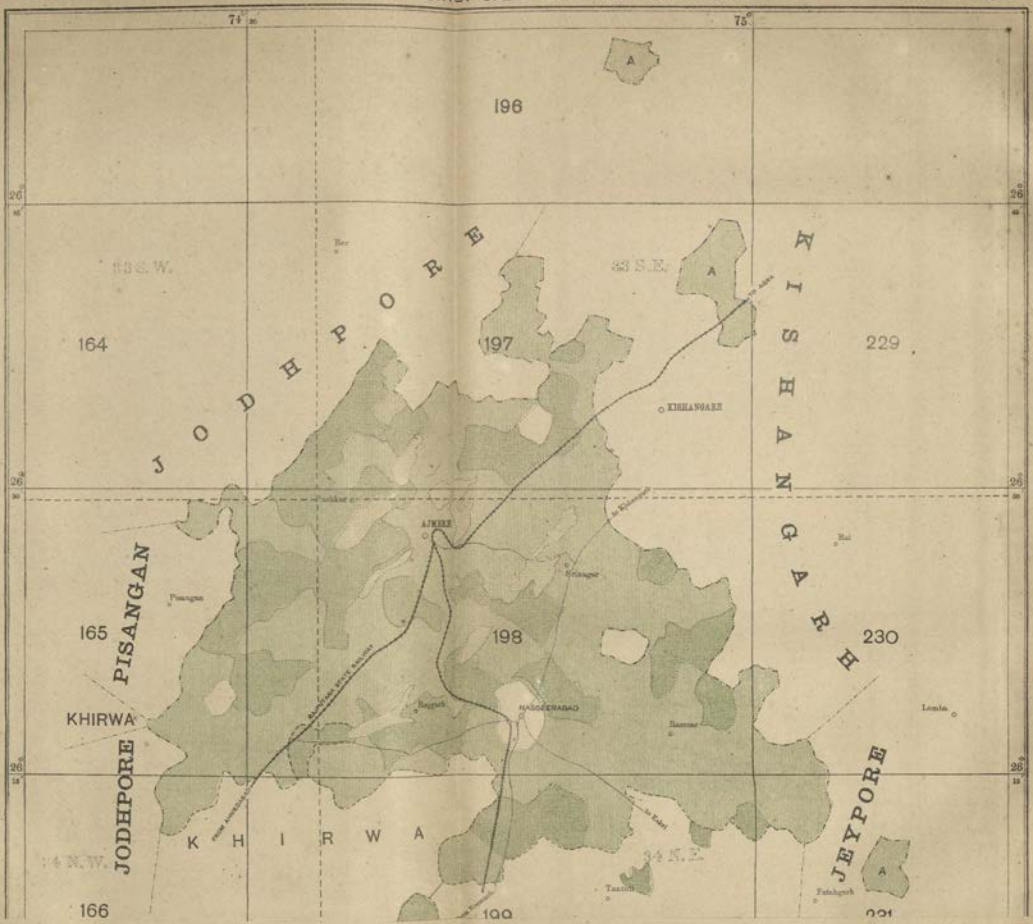
208. Before the survey was stopped, there had been sent to the Settlement Officer the records of 591 villages containing 474,047 fields with an area of 204,293 acres or 319·21 square miles. Of these, 235 villages have subsequently been published in the *Gazette* to be settled under the Act. They contain 139,929 fields with an area of 58,967·86 acres, or 92·14 square miles, and to these alone will the full benefits of the survey and settlement under the Bengal Tenancy Act apply.

209. The expenses incurred since 30th September 1886 have amounted to R7,707-12-3 which amount added to the expenditure of R1,23,566-5-9 prior to 30th September, gives the total sum of R1,31,274-2-0 as the entire cost of the experimental survey. A great part of this outlay has been incurred on account of maps and records that are now useless, though it may be hoped, only temporarily so. These comprise the cadastral maps and the vernacular village records of the area (95 square miles included in 65 villages) remaining to be given to the Settlement Officer, of which the field area calculations are nearly finished; and the skeleton traverse plots of about 900 villages surveyed in advance for another season's cadastral survey. The incomplete village records have been made over in the state they were in when the work was stopped, to the Settlement Officer at Mozufferpore; and all the original cadastral maps, along with the skeleton preparatory traverse plots, will be deposited in the Surveyor General's Office in Calcutta.

210. The camp office of the party was inspected by the Deputy Surveyor General in charge of the Revenue Branch at Mozufferpore on 15th March 1886.

AJMERE MERWARA.

INDEX TO THE SURVEY OPERATIONS IN DISTRICT AJMERE. No. 3 REV. PARTY.



The Deputy Surveyor General considers that very great credit is due to Colonel Barron for the amount of work he accomplished with a new establishment and in face of considerable difficulties accompanying the introduction of a cadastral survey with record of rights into a permanently settled district in Bengal. Colonel Barron's good services would, without doubt, have been more conspicuous had he been allowed to carry out the arrangements he had made for undertaking a very much larger area during a second season. The special Hand-Book he has compiled for cadastral survey with preparation of village papers in Behar will, it is believed, be of great value in future cadastral survey operations in that part of the Bengal Province, as well as of much assistance in similar work in Lower Bengal.*

TRAVERSE SURVEYS.

AJMERE DISTRICT, RAJPUTANA.

(DETACHMENT No. 3 PARTY, REVENUE BRANCH.)

211. This detachment, as explained in paragraph 158 of last year's Annual Report, was left in District Ajmere, on the withdrawal of the full party which had been employed on the survey of the *khalsa* villages during the previous season, for the purpose of surveying the boundaries of the *jagir* villages mixed up with the *khalsa* villages but of which the survey had not been sanctioned until receipt, during the recess season, of Government of India, Revenue and Agricultural Department, letter No. 241 S., dated 11th June 1885. Besides the *jagir* villages, the Government of India, Foreign Department, telegram No. 994-I., dated 25th March 1886, sanctioned, on the recommendation of the Chief Commissioner of Ajmere-Merwara, the survey of six minor *istimrar* (permanently settled) villages.

Personnel.

Mr. A. J. Gibson, Surveyor, 2nd grade, in charge, from 1st November 1885.
Mr. F. B. Powell, Assistant Surveyor, 3rd grade, from 23rd September 1886.
10 Sub-surveyors and others.

212. The detachment was placed under the charge of Mr. A. J. Gibson, Surveyor, 2nd grade, and it arrived in Ajmere from Mussooree (the recess quarters of the party from which it was drawn) on 1st November 1885. Lieutenant-Colonel E. H. Steel, Deputy Superintendent, who had charge of the Ajmere-Merwara survey during the previous season, though transferred to another province, was directed to exercise a general supervision over the detachment.

213. The work has consisted, as hitherto, of the construction of a village traverse basis suitable for being used for a survey of the fields by *patwaris*, added to which there has also been a survey of the actual boundaries of the villages, and skeleton maps showing both traverse stations and boundaries have been projected and drawn. Two copies of each skeleton map are prepared; one copy is for the use of the *patwari* working under the Settlement Officer, and the second copy is intended to serve for a standard from which other copies may be taken either by photo-zincography or otherwise whenever a revision of the *patwari's* first survey is required. The skeleton maps, as first drawn, are, however, not considered final, as it is found that differences in the boundaries are obtained during the more complete survey of fields by the *patwaris*, and the standard copies of the maps are amended when necessary on receipt from the Settlement Officer of a corrected tracing of the discrepant parts of the boundaries. The final computations of village areas must also be deferred until the sketches of the discrepancies have been received.

214. The detachment has surveyed, during the past season, 51 *jagir* villages and 6 *istimrar* villages, comprising an aggregate area of 243 square miles. The old traverse stations of the *khalsa* villages have been available for a large part of the traversing. They have been supplemented by 2,019 new stations which as usual have been marked with special stones, $16'' \times 6'' \times 4''$, having a distinguishing mark cut on them. The boundary pillars were usually substantial slabs of stone, embedded firmly in the ground, but occasionally piles of

* Colonel Barron reports that the European staff of the party have all worked well, mentioning the names of the seniors, Messrs Wilson, R. B. Smart and Shaw, and the juniors Messrs. Hughes, A. B. Smart and Lee, in connection with the shares they respectively took in the different operations.

Favourable mention is made of the following members of the native establishments, *viz.*, of the permanent establishment, Shaikh Abdullah, Pyari Ram, Manohar Lall, Gunga Bishen, Shamsudin, Salik Ram, and Gajadhar. Of the temporary establishment, Ishar Chandar, Jankee Parshad, Amir Khan, Kanay Raie, Jowala Parshad, Chetram, Raghubir Saran, Abdul Majid, and Bhikhan Khan.

loose stones had been erected instead, which gave much trouble owing to their having been frequently moved during the survey. Many of the boundaries lay in very rugged country, where it was extremely difficult to obtain good chain measurements. One forest reserve has been surveyed on the 4-inch scale at the request of the Forest Department, and the map of the same along with 20 other Forest maps surveyed during the previous season, have been sent to the local Forest Officer. The 57 villages comprising the season's out-turn have been mapped on 266 sheets, copies of which were duly furnished to the Settlement Officer, but as yet the sketches of discrepancies of the boundaries due from that officer have only been received for two villages, so most of the standard sheets are not finally disposed of and their areas are not computed.

215. The standard sheets of the *khalsa* villages of Ajmere surveyed during the previous season have been amended according to the *patwaris'* surveys of the boundaries, and the final areas have been furnished to the Settlement Officer.

216. The amendment of the boundaries on the sheets of Merwara surveyed during the previous season, according to the corrected tracings sent by the Settlement Officer, has been carried out in the office of the Rajputana Party which was engaged on topographical work in that part of the Ajmere-Merwara District; but the boundary amendments only have been done, and the final computations of area still remain. Since the breaking up of the Ajmere detachment, these computations have been carried on in the Surveyor General's Office by computers brought down from one of the field parties for the purpose.

217. A recommendation was made by the Chief Commissioner, Ajmere-Merwara, in letter No. 589-562-II, dated 5th June 1886, to the Secretary to the Government of India, Foreign Department, for the extension of the village boundary survey to the *istimrar* (permanently settled) villages in Parganas Bhinae, Masuda, Kekri, Khirwa and Pisangan of District Ajmere, which cover an area of about 1,240 square miles or more than half the district. The Government of India were prepared to sanction this survey on the understanding that the cost would be defrayed by the *Istimrardars*, (Government of India, Foreign Department, letter No. 3084-I, dated 30th August 1886); but on the *Istimrardars* declaring to the Chief Commissioner their inability to meet the necessary expenses, the project was given up.

218. The recess office of the detachment was inspected at Mussooree during September 1886, by the Deputy Surveyor General in charge of the Revenue Branch, who was satisfied with the pains being taken by Mr. Gibson to ensure accuracy in the records.*

JUBBULPORE AND DAMOH DISTRICTS, CENTRAL PROVINCES.

(No. 9 Party, Revenue Branch.)

219. This party, which has been formed on the remnant of the Malwa Topographical Party as a nucleus, has been raised in accordance with the instructions conveyed in letter No. $\frac{396}{88\text{-}10}$ S., dated 2nd September 1885, from the Secretary to the Government of India, Revenue and Agricultural Department, to the Surveyor General of India, to carry out a village boundary traverse survey in the districts of Jubbulpore and Damoh to constitute a basis for a survey of the fields to be done by the *patwaris* of the respective districts. The members of the party, many of whom were newly entertained, while some were transfers from other parties, began to assemble at Jubbulpore on 1st November 1885, and were there distributed into two sections, both of which under the two senior Surveyors commenced operations in the two districts simultaneously on 20th November. Field work was continued until the end of

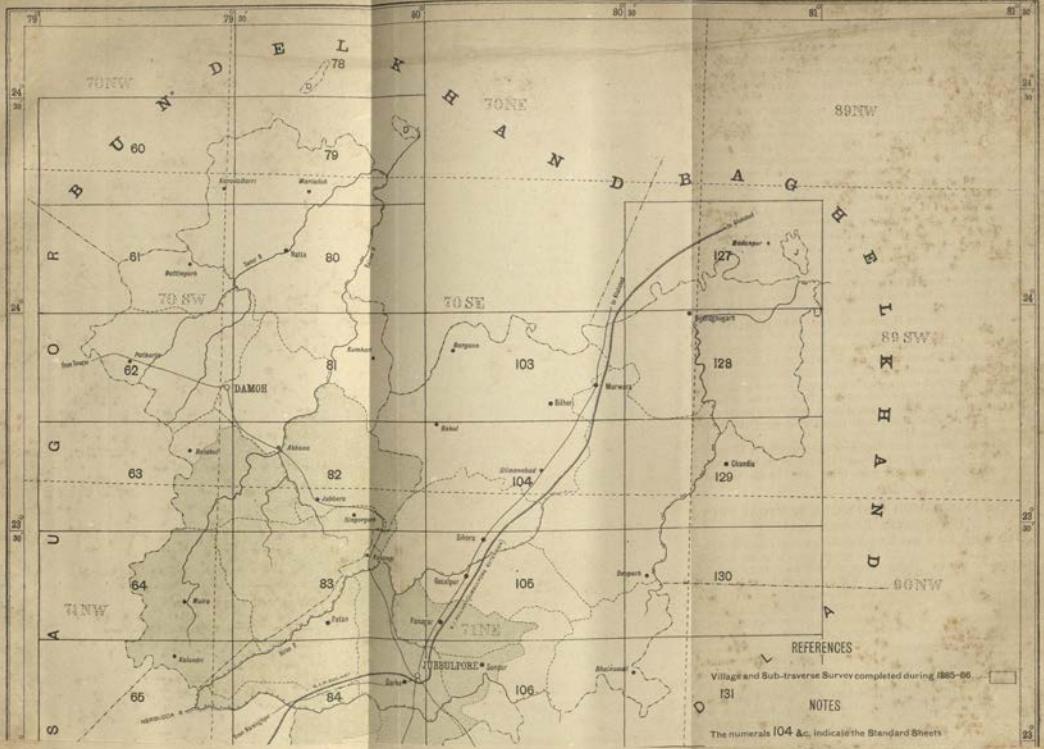
Personnel.

Mr. W. H. Patterson, Officiating Deputy Superintendent, 4th grade, in charge, up to 26th October 1885.
" G. H. Cooke, Officiating Deputy Superintendent, 3rd grade, in charge, from 27th October 1885.
" J. A. May, Surveyor, 1st grade, up to 5th November 1885.
" J. Todd, Surveyor, 2nd grade.
" H. Dowman, Surveyor, 3rd grade, from 1st November 1885.
" J. T. U. Coxen, Surveyor, 4th grade, from 1st November 1885.
" R. R. Dickenson, Assistant Surveyor, 1st grade, up to 30th April 1886.
" G. Vanderbeck, Assistant Surveyor, 1st grade, up to 31st October 1885.
" E. P. S. Hill, Assistant Surveyor, 1st grade, from 29th April 1886.
" C. George, Assistant Surveyor, 2nd grade, up to 31st October 1885.
" J. A. Higgs, Assistant Surveyor, 2nd grade, up to 30th June 1886.
" A. Ewing, Assistant Surveyor, 2nd grade, from 1st November 1885.
35 Sub-surveyors and others.

* Mr. Gibson reports most favourably on the services of Sub-surveyor Abdul Karim.

CENTRAL PROVINCES SURVEY.

INDEX TO THE SURVEY OPERATIONS IN DISTRICTS JUBBULPORE AND DAMOH.



May, when the office establishments of both sections proceeded to Mussooree for recess.

220. The requirements of the Chief Commissioner with regard to the traversing are laid down in letter No. 226S., dated 8th April, from the Officiating Junior Secretary, addressed to the Secretary, Government of India, Revenue and Agricultural Department, in which letter the Central Provinces experiment of a survey of blocks of fields is finally condemned, and two matters of essential importance to secure an accurate field survey by *patwáris* are mentioned, *viz.*, (1) The traverse lines must follow village boundaries closely. *(This was afterwards explained to mean that the lines should be sufficiently near the boundary marks to enable the patwaris to plot them by offsets without difficulty).* (2) The traverse stations must not be more than 30 chains apart. These two points have been strictly attended to, and while the specified distance of 30 chains has never been exceeded, the average length of the traverse lines is 15 chains. The distance of 30 chains has also been adopted as the interval at which the sub-traverse lines have been placed in large villages to cut them up into polygons of suitable size to constitute a frame-work for the survey of the fields. Another stipulation made by the Administration of the Central Provinces was for all the traverse stations to be marked in a substantial manner. This has been attended to in the first place by adopting the existing masonry marks at village trijunctions as traverse stations, and, secondly, by placing at all other stations a roughly-cut stone prism, 2 feet long by 6 inches in thickness. Sometimes the bends of the village boundaries were found to be marked with slabs of stone, instead of with mounds of earth, and where these slabs existed, the use of the special stones was saved; but boundary demarcation of this kind is not common either in the Jubbulpore or Damoh District, and stone marks had almost universally to be adopted and put down by the surveyors. The number of stones put down in both districts was 32,097 at a total cost of ₹5,571, the average number of stones to the square mile on the area surveyed being 14½ and the average cost ₹2-8 per square mile. The cost does not include any share of the pay of the men engaged on the survey who put down the marks as part of their survey duties.

221. The following statement shows the work which has been done in the two districts separately:—

District.	No. of villages.	No. of sub-traverses.	Area. Square miles.	Remarks.
Jubbulpore . . .	864	1,162	965	
Damoh	519	653	1,250	
TOTAL .	1,383	1,815	2,215	

The total cost of the operations up to 30th September was ₹76,012 which gives a cost rate per square mile of ₹34-5-1. Excluding ₹5,571, the cost of the stone marks, and an unusually heavy expenditure—₹2,564—for line-clearing due to the jungle-clad country, the rate per square mile is reduced to ₹30-10-4.

222. The number of skeleton sheets on the 16-inch scale, on which the village traverses will be plotted for the *patwari* survey, is estimated to be over 4,000, but the plotting is somewhat delayed owing to the difficulties that have been met with in bringing up the computations of the very intricate traverses in the hilly and raviny tracts. Copies of the traverse data of the villages and area statements of the village polygons are being prepared for record in the office of the Commissioner of Settlements and Agriculture.

223. In the programme for traverse surveys in the Central Provinces, as detailed in letter No. 569S., dated 10th August 1885, from the Officiating Junior Secretary to the Chief Commissioner, to the address of the Secretary to the Government of India, Revenue and Agricultural Department, the areas for survey in Jubbulpore and Damoh are set down at 3,550 and 1,938 square miles respectively. These areas are found to be exclusive of the areas of the forests which, it had been expected, need not have been calculated with the areas for

survey, but the forests are so much intermingled with the village lands that they have to be traversed in the same way as villages, except that they have not to be cut up by sub-traverses; and thus adding the forest areas, the real areas for survey are:—Jubbulpore, 3,948 square miles; Damoh, 2,831 square miles. Deducting what has been done, the areas remaining are:—Jubbulpore, 2,983 square miles; Damoh 1,581 square miles.

224. The office of the Jubbulpore section of the party was inspected by the Deputy Surveyor General in charge of the Revenue Branch in camp at Jubbulpore during March; and again, the recess office of the whole party was inspected by the same officer at Mussooree during September. The Deputy Surveyor General found that very great pains were being taken to ensure accuracy in all parts of the work, and he considers that the progress made towards the completion of the computations of the traverses of a difficult country with a new establishment was satisfactory.*

PUNJAB PROVINCE.

(No. 1 Party, Revenue Branch.)

225. This party, under Lieutenant-Colonel F. Coddington, having closed its recess office at Simla on 16th October 1885 and collected its field establishments at Ludhiána by 24th October, moved in two sections into Districts Ludhiána and Umballa for a continuance of the operations of the previous season. The operations were subsequently extended into Districts Jullundur, Hoshiárpur, and Gurdáspur and into the Kapurthala State. Field operations were continued by one section up to 10th May 1886, and by the other until 18th May, when the establishments being again reduced, the party returned to Simla.

Personnel.

Lieutenant-Colonel F. Coddington, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. H. E. T. Keelan, Surveyor, 1st grade, from 22nd October 1885 to 24th April 1886.
Mr. J. S. Pemberton, Surveyor, 2nd grade, from 21st October 1885.
Mr. C. W. Wilson, Asst. Surveyor, 1st grade,
„ G. Campbell „ 1st „
„ J. P. Barker „ 2nd „
„ F. P. Walsh „ 3rd „ from 4th March 1886.
30 Sub-surveyors, &c.

226. The work on which the party is engaged, and which is fully described in paragraphs 239, 240, and 247 of the Report for 1884-85, may be briefly described under the following heads, *viz.*:—

(1) The skeleton traversing of villages for the purpose of determining the co-ordinate distances of tri-junction points; and the projection of maps of the tri-junctions on the scale of 2 inches to the mile.

(2) The insertion of topographical details on these maps by reduction from the settlement survey village maps.

(3) The testing and correcting (when necessary) the reduced maps by examination in the field.

(4) The drawing of fair maps on the 2-inch scale.

227. The areas accomplished under these separate heads in the several districts are as shown below:—

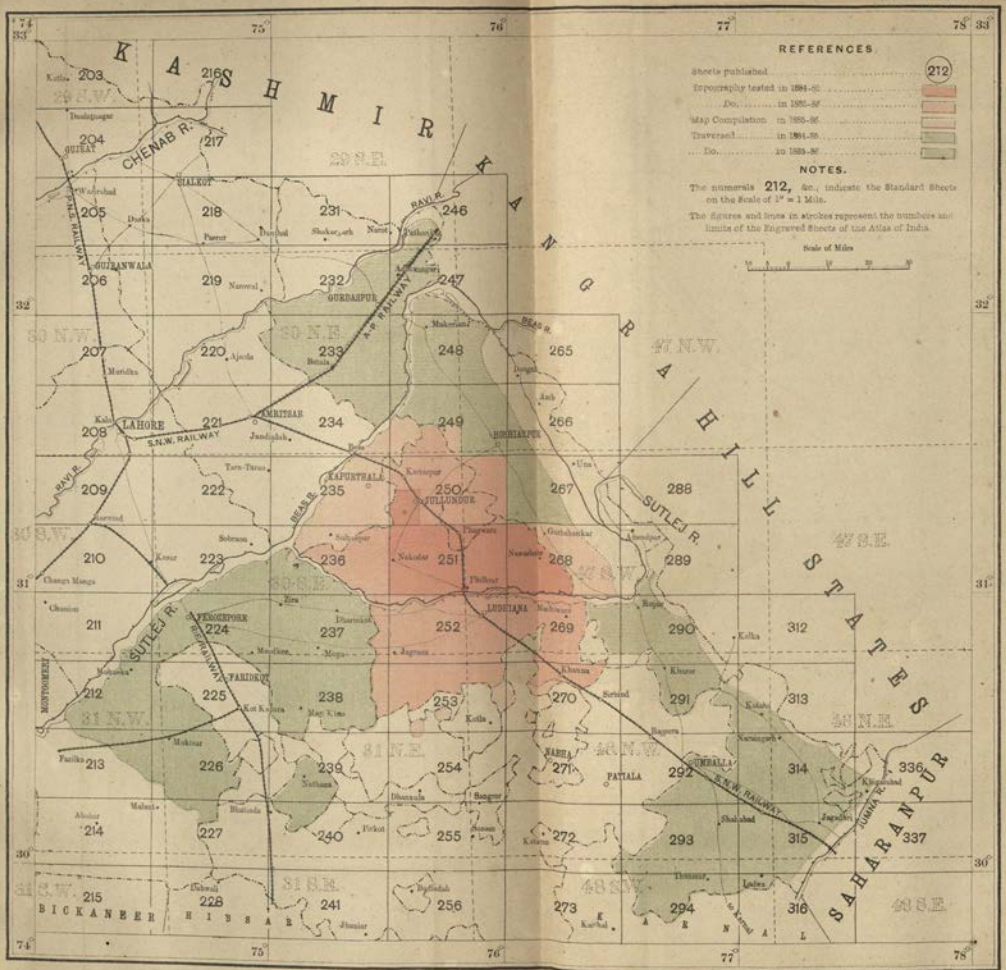
District.	(1) Area traversed.	(2) Area mapped by reduction.	(3) Area tested.	(4) Area finally mapped.
	Square miles.	Square miles.	Square miles.	Square miles.
Gurdáspur	1,070	...	...	...
Hoshiárpur	1,380	758	314	301
Jullundur	20		690	781
Kapurthala (State)	500	748	588	358
Ludhiána	70		1,328	1,184
Umballa	730	416	...	...
TOTAL	3,770	1,922	2,920	2,624

* Mr. Cooke in his Report mentions the names of all his European assistants favourably, giving particulars of the share each had taken in the work of the season. He commends the following members of the native establishment, *viz.*:—Taraprosonnoo Roy, Kally Prosonnoo Nag, Upendra Nath Mukerji, Monohar Daji, Bani Madho, Irfan Ali, Mahadeo Daji, Mahmud Bux, Rur Singh, Gopal Setaram, and Kesho Vaijnath.

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE PUNJAB.

No. 1 REV. PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

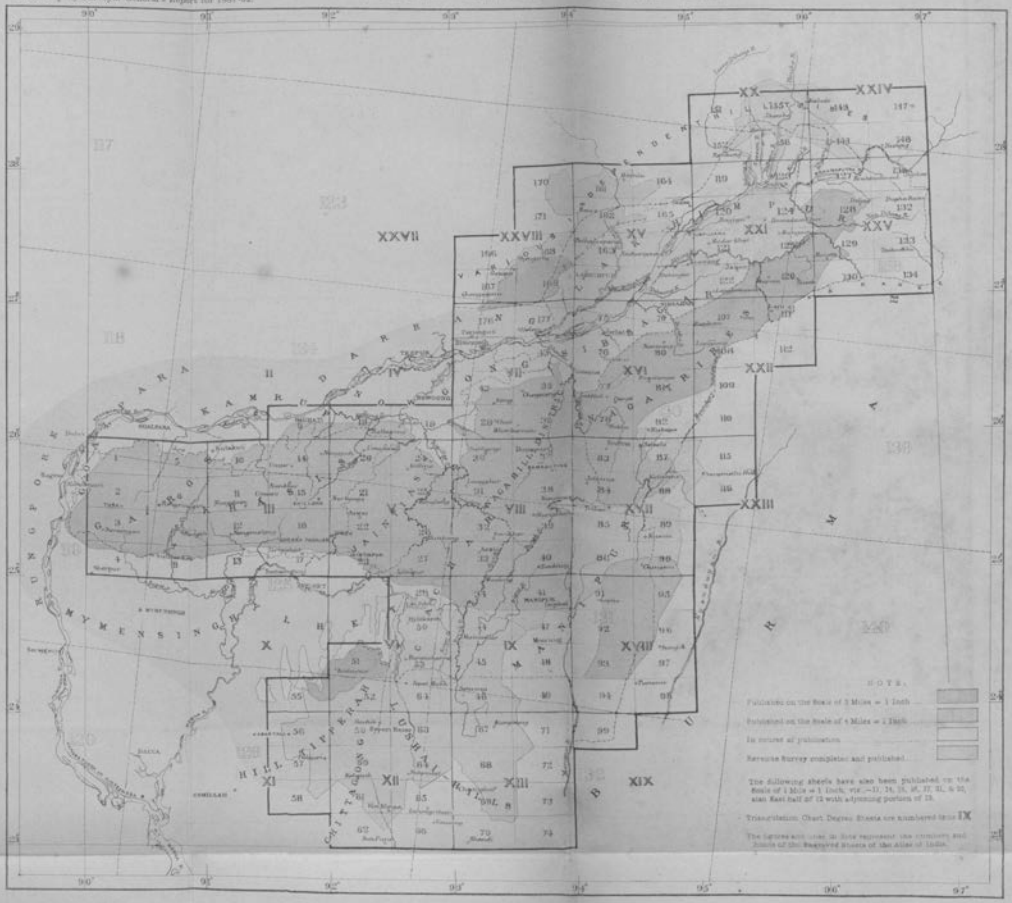
Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India,*
Survey of India Office, Calcutta, September 1886

No. 6 PARTY.

INDEX TO THE SHEETS OF THE GARO, KHASI, AND NAGA HILLS AND NORTH EAST FRONTIER TOPOGRAPHICAL SURVEY,

To accompany Surveyor General's Report for 1881-82.

On the Scale of 1 Inch = 1 Mile, ½ Inch = 1 Mile, and ¼ Inch = 1 Mile.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, March 1883.

228. The operations under heads (1), (2), and (3) have been completed in Districts Jullundur and Ludhiána and in the Kapurthala State; and under head (1) only in districts Hoshiárpur and Umballa. About two-thirds of the Gurdáspur District has been completed as regards head (1). The hilly portions of these districts have not been included in this survey.

229. The reductions from the settlement survey maps when tested were found to be very correct representations of the ordinary topographical features, and only a few omissions had to be supplied by new surveys. Usually these were bridges, temples and mile-stones; and the limits of the village sites and the high banks of rivers had sometimes to be revised.

230. Sheets 250 and 252 have been completely mapped and are ready for publication. At present the publication will be on the reduced scale of 1 inch to the mile, but the four 2-inch sections on which the original drawing has been done, are suitable for publication separately on the original scale if ever required. Sheet 253 is drawn on the 2-inch scale as far as it includes portions of revenue-paying districts. A separate drawing of the portion of this sheet, which includes parts of Sikh States, will be prepared on the 1-inch scale, from the old surveys of these States, and the separate drawings having been combined, the entire sheet will be printed showing all the available topography. Sheet 268 is drawn, as far as materials are available, from the settlement survey village maps, but the hill portion of the Hoshiarpur District falling within the sheet, remains for survey by the Himalaya Party.

231. Mr. G. Campbell, Assistant Surveyor, was deputed between 19th November 1885 and 25th January 1886, to assist a civil officer in re-fixing old pillars on a disputed portion of boundary between the Sialkot District and Kashmir territory.

232. The recess office of the party was inspected during September by the Officiating Surveyor General, who was entirely satisfied with Colonel Coddington's management of the party and with the systematic arrangements for carrying out the large amount of work that now devolves on his office, as, in addition to the ordinary work connected with the survey and with the fair mapping thereof, various records are prepared for the Settlement Department, which has added considerably to the recess duties. The records and maps were found to have been well prepared, and the general efficiency of the party was well demonstrated.*

RAIPUR DISTRICT, CENTRAL PROVINCES.

(No. 3 PARTY, REVENUE BRANCH.)

233. This party, which had been employed during the previous season on a traverse and village boundary survey in Districts Ajmere and Merwara, was transferred, under orders from the Government of India conveyed in Revenue and Agricultural Department letter No. $\frac{396}{36-10}$, dated 2nd September 1885, to the Central Provinces to carry on a skeleton traverse survey in the Raipur District in aid of a field survey, which would be executed by the district *patwaris*. A small detachment of the party was left in Ajmere for the boundary survey of *jagir* villages, as referred to in paragraph 158 of last Report. The party on its removal to Raipur was placed under charge of Lieutenant-Colonel W. H. Wilkins, Major (now Lieutenant-Colonel) E. H. Steel having been transferred to No. 2 Party for the cadastral survey of the Bilás-pur District.

Personnel.

Lieut.-Col. W. H. Wilkins, S.C., Officiating Deputy Superintendent, 2nd grade, from 4th November 1885.
Major E. H. Steel, S.C., Officiating Deputy Superintendent, 3rd grade, up to 3rd November 1885.
Mr. A. D'Souza, Officiating Assistant Superintendent, 1st grade, up to 31st March 1886.
Mr. A. J. Gibson, Surveyor, 2nd grade, up to 31st October 1885.
„ W. S. Buttress, Surveyor, 2nd grade.
„ A. Christie, Surveyor, 3rd grade, from 1st January 1886.
„ J. R. Scott, Assistant Surveyor, 1st grade, from 1st November to 31st December 1885.
„ C. W. F. Seyers, Assistant Surveyor, 1st grade, up to 31st October 1885.
„ G. Vanderbeck, Assistant Surveyor, 1st grade, from 1st November 1885.
„ E. F. Berkeley, Assistant Surveyor, 2nd grade, from 1st November 1885.
„ T. W. Babonau, Junior, Assistant Surveyor, 3rd grade.
28 Sub-surveyors and others.

234. The field establishment assembled

* Colonel Coddington reports satisfactorily on the services of Messrs. Keelan, Pemberton, Campbell, Barker, and Walsh; and names the following members of the native establishment as the most worthy of mention, *viz.*, Elahi Bux (1st), Eed Mahomed, Serajudin, Awaz Ali, Ramjas, Elahi Bux (2nd), Maula Bux, and Daswandhi Ram.

at Raipur on 15th November, and field operations were continued up to 15th May, when the office establishment proceeded to Mussooree for recess work. Regarding the retention of the party in the field during May, which was done under an endeavour to complete a proposed area, the Deputy Superintendent reports that very little work was done on account of the intense heat and the many cases of sickness, and he considers there is no adequate return for the expense of keeping up field establishments for a day after 30th April at the latest.

235. The Central Provinces system of "field block" survey having been found unsatisfactory and finally abandoned, as mentioned in paragraph 263 of last Report, the character of the work required of this party and of other traverse parties in the Central Provinces has been that of a simple skeleton traverse, not taking up village boundaries, similar to what is carried on in cadastral survey parties preparatory to the survey of the fields by professional *amins*, except that in the Central Provinces, the Chief Commissioner has stipulated on the following modifications of the ordinary skeletons, *viz.*, that the traverse lines should follow the village boundaries somewhat more closely, and that the interior lines in large villages should be at slightly reduced intervals, so that the work may be rendered easier for the village *patwaris*, who will take the place of experienced *amins*. It has also been stipulated that every theodolite traverse station, whether on the boundary or in the interior of villages, should be permanently marked with a substantial stone.

236. The traverse survey has been extended to the north-east, east, and south-east of the central part of the Raipur District, for which the "field block" survey had been completed, as reported in paragraphs 142 to 154 of the Report for 1883-84, and has covered a total area of 2,169 square miles. The total area is comprised in 13 main circuits which were surveyed by the European officers. These officers also took observations at 135 stations for azimuth; and, when otherwise unemployed, they moved about among the villages examining the mark-stones put down by Sub-surveyors at theodolite stations and giving injunctions to the headmen of villages concerning the protection of these stones.

237. During the field season, 317 skeleton plots on the 16-inch scale were supplied to the Settlement Officer for the field survey by *patwaris*, and 403 more were sent during the recess. The remaining plots will be supplied during the next field season. Copies of the village traverse data are being prepared to be lodged in the office of the Settlement Commissioner to enable fresh plots to be issued from his office whenever new surveys are required. Statements of the areas of village traverse polygons are also being prepared for the Settlement Commissioner's office.

238. The recess office of the party was inspected at Mussooree during September by the Deputy Surveyor General in charge of the Revenue Branch, who reports most favorably of the state of the records and of the organization of the party as brought about by Colonel Wilkins' able management.*

SAMBALPUR DISTRICT, CENTRAL PROVINCES.

(DETACHMENT FROM NO. 3 PARTY, REVENUE BRANCH.)

239. This detachment left its recess quarters at Nagpur under charge of Mr. P. A. G. Cowley, Surveyor, 1st grade, on 7th November 1885, and arrived in the Sambalpur District to resume operations there on 22nd idem. Mr. Cowley remained in charge until 23rd March 1886, when, under urgent medical advice, he was obliged to leave the district on account of severe illness, making over charge temporarily to Mr. C. S. Kraal, Assistant Surveyor, 1st grade, who was relieved by Mr. A. D'Souza, Assistant Superintendent, on 10th April.

Personnel.

Mr. A. D'Souza, Officiating Deputy Superintendent, 4th grade, in charge, from 11th April 1886.
„ P. A. G. Cowley, Surveyor, 1st grade, in charge, up to 22nd March 1886.
„ C. W. F. Seyers, Assistant Surveyor, 1st grade, from 1st November 1885.
„ C. S. Kraal,* Assistant Surveyor, 2nd grade.
„ E. F. Berkeley, Assistant Surveyor, 2nd grade, up to 31st October 1885.
18 Sub-surveyors and others.

* Was in temporary charge from 23rd March to 10th April 1886.

* Colonel Wilkins, mentioning the names of his senior assistants, Messrs. Buttress and Christie, states that they have given him great satisfaction; and regarding the juniors, Messrs. Vanderbeck, Berkeley and Babonau, that they have also worked satisfactorily.

Of the native establishment, Colonel Wilkins mentions favorably the names of English Writer, Bhagobutty Churn Chuckerbutty, Head Computer Kedar Nath, Draftsman Surfraz Khan, Sub-surveyors Mahomed Zakaria and Alladad Khan, and of Hospital Assistant Golam Mahomed Khan.

CENTRAL PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTRICT SAMBALPUR.

DETACHT. No. 3 REV. PARTY.

Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., Officiating Surveyor General of India, Survey of India Offices, Calcutta, December 1866.

240. A very important change has been introduced in the work required of this party owing to the abandonment by the Central Provinces Administration of the experimental system of "field block" survey, as reported in letter No. 226S., dated 8th April 1885, from the Junior Secretary to the Chief Commissioner, to the Secretary to the Government of India, Revenue and Agricultural Department. In place of the "field block" survey a simple traverse survey has been substituted for the purpose of furnishing skeleton maps, on which the *patwaris* will now plot all the necessary field measurements, instead of, as formerly, fitting their measurements of single fields within the field blocks.

241. Under the new system, the theodolite stations corresponding with the points on the skeleton maps, are required to be marked in a permanent manner, which has been accomplished most inexpensively by utilizing stones which had been laid down to mark bends of the village boundaries, while special stones had only to be fixed at the sub-traverse stations in the interior of large villages. These survey stations were all counted and delivered to the charge of the headmen of villages, from whom receipts were obtained, so as to fix the responsibility for the proper preservation of the marks.

242. The season's out-turn comprises 436 villages of Tahsils Bargarh and Sambalpur and covers an area of 885 square miles. Besides the village boundary traverses, there are, in all, 601 sub-traverses in large villages; and the number of skeleton sheets is 735. The sheets of 124 villages, covering an area of 190 square miles, were furnished to the Settlement Officer during the field season, and the remainder at the end of the recess. Observations for azimuth were taken at 55 traverse stations. Connections were made on 9 G.T.S. stations, enabling 8 comparisons to be made between triangulation and traverse distances which show the latter to have an average error of 1·45 feet per mile.

243. The Assistant Superintendent now in charge of the detachment reports as follows on the unhealthiness of the district:—

"Although the precaution had been taken not to enter the district too early, owing to the malarious character of the country, yet the party suffered very much from sickness. Mr. Cowley was so prostrated by repeated attacks of fever and dysentery that he was obliged to apply for leave on medical certificate for 15 months, and he left the district in a very critical state. Both the European assistants suffered also very much. The average number of the sick among the native establishment throughout the field season was 30. With the exception of two men, the whole of the Sub-surveyors suffered more or less from fever, and out of the office hands only one man kept good health."

244. The total area traversed in the Sambalpur District during two seasons is 1,502 square miles, and about 937 square miles remain to complete what is required in the district.

245. Mr. D'Souza has furnished a short descriptive account of the Sambalpur District, which is printed in the appendix, page xviii. Regarding the country surveyed he writes as follows:—

"The ground under survey during the year, with the exception of a portion of Bargarh and that in the vicinity of the town of Sambalpur and along the banks of the Mahánadi River, is by no means favorable for survey operations. It embraces the forest reserves and hilly tracts which are so densely covered with forest and bamboos that it was with the greatest difficulty the surveyors cut their lines through them."*

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* Mr. D'Souza reports on the services of his assistants as follows:—

"Both Messrs. Seyers and Kraal have worked well, and I have to make special mention of Mr. Kraal (selected for the temporary charge of the party on Mr. Cowley's departure), who has fully borne out the excellent character given him by my predecessor as an intelligent and hard-working assistant."

The following members of the native establishment are named as specially deserving of mention, *viz.*, Boith Ram, Koylash Chandar, Habibulla, Changa Khan, Niladhur, Ram Dass, Ramcharan, Abdul Khalik, Mahamed Hosein, Abdul Karim, Giyadin, Sadik Hosein, and Hospital Assistant Ram Sahai, who is said to have been most attentive to the sick.

GEOGRAPHICAL AND MISCELLANEOUS.

HIMALAYA PARTY.

246. As stated at page 53 of the Annual Report for 1884-85, the *locale* of the future operations of this party being no longer confined to the vicinity of Darjeeling, its designation was altered to that above given. The several works taken up are as follows:—

Personnel.

Colonel H. C. B. Tanner, S.C., Deputy Superintendent, 2nd grade, in charge, except between 21st April and 19th August, while on duty with the Tibet Mission.
Captain R. A. Wahab, R.E., Deputy Superintendent, 4th grade, from 14th April 1886, and held charge in Colonel Tanner's absence.
Lieutenant W. H. Pollen, R.E., Deputy Superintendent, 4th grade, up to 18th March 1886.
Lieutenant J. M. Fleming, S.C., Probationary Assistant Superintendent, 2nd grade, from 21st September 1886.
Mr. H. E. T. Keelan, Surveyor, 1st grade, from 1st April 1886.
„ W. Robert, Assistant Surveyor, 1st grade.
„ E. P. S. Hill, Assistant Surveyor, 1st grade, up to 12th April 1886.
„ F. E. Warde, Assistant Surveyor, 3rd grade, from 4th September 1886.
„ G. H. Powell, Assistant Surveyor, 3rd grade.

Sub-surveyors.

Shaikh Omar, from 26th December 1885.
Atma Sing, on duty with Tibet Mission, from 21st April to 19th August.
Ram Saran, Sahai Din, and five others.

(1) The demarcation of the Nepal-Bengal boundary on the Mechi River, and on the right bank of the Bágmati in the Mozufferpore District.

(2) The bringing up of the arrears of mapping and computations connected with the Nepal Boundary Survey, the Sikhim triangulation and the Darjeeling Revisionary and Daling Lands Surveys.

(3) A topographical survey (scale depending on the character of the ground to be surveyed) of the Hill States about Simla and of the Kángra District, and *pari passú* the accurate fixing of all tri-junction and *tikka** boundary marks and other permanent points, such as wells, temples, &c., situated within them, to afford a basis for the construction of the Settlement maps of the district.

(4) The Geography of the Himalayas.

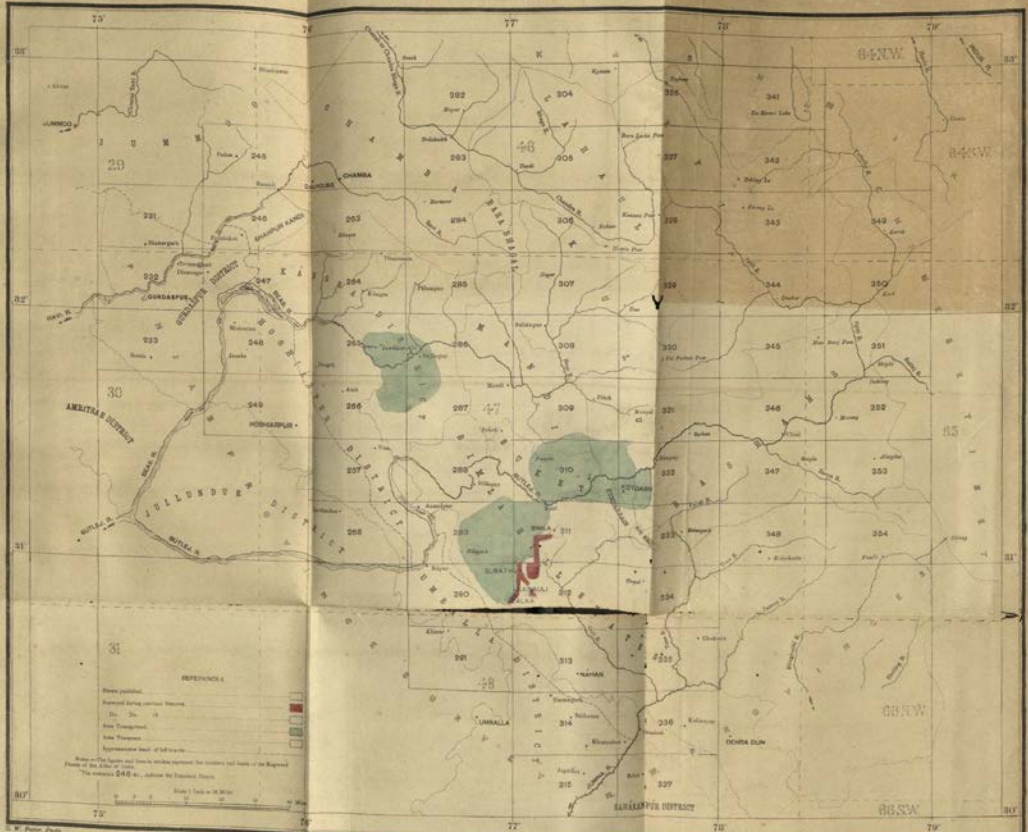
247. Regarding the Nepal-Bengal boundary, definite orders were not received till late in December, when an Assistant was immediately detached for the purpose. Twenty-four miles of boundary along the Mechi River were examined and demarcated by wooden posts erected at short intervals: of this distance, 7 miles, involving 236 acres, are disputed. After the boundary has been finally demarcated, permanent pillars (similar to those along other parts of the Nepal-Bengal boundary) will have to be erected at about one mile intervals and numbered from north to south in continuation of the Darjeeling District numbering. The demarcation near pillar No. 52 of the Mozufferpore District (left unfinished in 1884-85, see para. 269 of the last Annual Report) was also completed, and further west, a small portion of the boundary, which had been obliterated by floods in the Lál Bakia River, was relaid.

248. Of the arrears of mapping, computations, &c.; some little progress has been made with the computations, but it was not found practicable to do much more than arrange the field records and have them bound and indexed. These records however will need a great deal of time and labour to harmonize—as they pertain to different times and to works having different immediate objects in view—and as the whole strength of the party is needed for field work, they have been taken over just as they are by the Computing Section of the Trigonometrical Branch Office, where the results will be worked out in due course and published in the Synoptical Volumes of the North-East Longitudinal and the Assam Series. The whole of the sheets (Nos. 13 A to 45) of the Nepal Boundary Survey were finally examined, completed and made over for publication; the skeleton sheets of the Daling Lands Survey were also completed, but the corresponding hill-shaded sheets have still to be drawn, as have also those for the 2nd edition of the Darjeeling Revisionary Survey.

* A *tikka* is a sub-division of a *mauza*, and a *mauza* includes an area within convenient and generally natural limits and all the habitations therein. A *tikka* might perhaps be called a hamlet, but that would signify a small village subordinate to a larger one, whereas several *tikkas* go to make up a *mauza*.

INDEX TO THE SHEETS OF THE PUNJAB

CONTAINING THE SIMLA HILL STATES, KANGRA, AND PARTS OF CONTIGUOUS DISTRICTS



Published under the direction of Lieut.-Colonel R. S. Thuillier, R.E., Offg. Surveyor General of India.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dun, March 1907.

249. For the topographical work the party broke ground about the middle of November 1885, in the Kángra District, in Sheet 265 (*vide* accompanying Index Map), and for the next three months was engaged in triangulating, traversing *and skeleton plane-tabling on the 16-inch scale. Experience soon proved the necessity for a change in the *modus operandi*, and instead of the 16-inch scale skeleton plane-tabling, a 4-inch survey in open style was introduced, suitable for a reduced 2-inch map, together with the fixing of the tri-junctions of *tikkas* and other suitably marked points by traversing, so as to furnish a convenient circuit of observed points in each *tikka*. The requisition for these changes is set forth in the note and letter following.

Note dated 13th February 1886, by COLONEL E. G. WACE, *2nd Financial Commissioner, Punjab, on the connection between the Survey of India and the Patwari Survey in the Kángra District.*

I have had an opportunity to-day of discussing with Colonel Tanner the connection of his work in the Kángra District with the local *patwari* survey, and I now record the system, which I am prepared to accept as meeting all local requirements—both revenue requirements and those of the general administration :—

(1) The observation of points, whether by traverse or otherwise, to be so made as to take up all known tri-junction points of hamlets (*tikkas*), and also to furnish a convenient circuit of observed points in each *tikka*. The Deputy Commissioner will arrange for all tri-junction points to be shown to the surveyor by the *patwari*.

(2) A plotted sheet showing the points so observed in each *tikka* to be made over to the Deputy Commissioner, a separate sheet for each *tikka;* the scale of this sheet to be 40 (equals 27·547 inches to the mile) local *kadams* (57½ inches each) to the inch.

(3) And also a table of co-ordinates of each *tikka*. This table will, in addition to the data, give a short description of each point.

(4) All points thus observed, which are not tri-junction pillars of *pakka* masonry, will be adequately marked on the ground, and formally made over by the surveyor to the *lambardar* and *patwari*, with a list thereof. This list will contain a topographical description of each point, corresponding with that provided above under head (3).

(5) No linear, that is to say, continuous village boundaries will be recorded by the Survey of India. *Tahsil* boundaries will be shown, also boundaries which in the Deputy Commissioner's opinion have a political importance, such as those of the *jagirs* of Siba, Goler, Lambagraon, Waigiri Rupur, &c., but in no case in minute detail.

(6) In respect of topography what is wanted is, sheets drawn in a free, open style on a scale of 4 inches to the mile, such as will be sufficient for the production of a 2-inch topographical map. All fixed points will be shown.

(7) The surveyor will show in his topographical sheets any forest boundary pillars of which a list is furnished to him. He will not be responsible for the linear boundary between pillars. A plot and table of each forest so observed will be furnished to the Deputy Commissioner, as provided under heads (2) and (3) above.

(8) The cost of the plotted sheets will be provided by the Deputy Commissioner under local arrangements, which that officer will settle in communication with the controlling revenue authorities.

(9) Copies of the 4-inch topographical sheets will be supplied to the Deputy Commissioner by the Survey of India, in the usual way.

(10) The survey will include the hill tract (Kolaba) of the Umballa District, and also the hill tract (Shahpur Kandi) of the Gurdáspur District.

(11) Colonel Tanner is at present working in the low hills of the Kángra District (Hamirpur and Dera), and will take up work in the higher mountains (Kullu Sub-division and similar tracts). This arrangement is well suited to local revenue requirements.

Letter No. C.—9 of 9th September 1886, from CAPTAIN J. A. L. MONTGOMERY, *Director of Settlements and Revenue Records, Punjab, to Colonel H. C. B. Tanner, Deputy Superintendent, Survey of India, in charge Himalaya Party.*

I am directed by the Financial Commissioner to address you in continuation of Financial Commissioner's No. 1517, dated 8th March 1886, and to request you to adopt, in lieu of the plan laid down in head (2) of the instructions therewith forwarded, the following system for plotting the traversed points of your survey on sheets intended for use as *patwari* field maps.

2. (A) For each *mauza* a plot of the traversed points is required on the scale of 80 local *kadams* to the inch.

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* Owing to the difficulty in carrying on chain measurements of ordinary traversing over hilly and broken ground, Colonel Tanner has introduced a method of determining the distances by measuring the angle subtended by a 20-foot rod, with a small portable theodolite, the intervening distance between them being of course 20 feet multiplied by the cotangent of the subtended angle which he measures with very great accuracy by the repeating process such as would be followed with the instrument known as a "repeating circle." The method has been found to answer admirably, and has been largely adopted by Colonel Strahan, R.E., in the Nicobar Survey, with very satisfactory results.

3. (B) For each *tikka* included in a *mauza* a similar plot is required on the scale of 40 local *kadams* to the inch. These large scale plots are not required for mountain areas which contain no scattered cultivation.

4. In case (A) the sheets should be ruled into squares; the side of the square measuring 15 chains. The same sheets can be used for case (B), though in this case the side of the square will represent a distance of $7\frac{1}{2}$ chains only.

5. You will observe that by adopting this plan, though the sheets will be projected (that is to say engraved in squares) with reference to the local scale, the points will be plotted by the English scale.

6. On one sheet of every *mauza* (case A above), and on one sheet of every *tikka* (case B above), a printed diagram showing the correspondence between the English and local measure should be pasted. The diagram should be biglot English and Urdu, and, so far as convenient, should be placed on the sheet in each village which is numbered "1."

Diagrams for the (1) Kángra District and Shahpur Kandi. (2) Morni Ilaka of District Umballa are appended.

7. The paper for the plotted sheets should be the same as is now in use by Colonel Coddington for the Hissar Survey. The size of the sheets used by him is 30" x 22", and the quality is imperial hand-laid blue. A good margin is required to right and left of the sheets on which will be recorded the field numbers in the interior survey.

8. Some other matters having been settled in joint discussion between the Financial Commissioner and yourself, a note thereof is added below.

9. The table of *tikka* co-ordinates should be in the same form as is used by the Punjab Survey, and the entries should be arranged in the same manner. Columns for which data are not calculated in the Himalayan Survey will be left blank.

10. Under the co-ordinates of each *tikka's* boundary (circuit) will be added those of any "additional points" observed.

11. It will be convenient if the work can be undertaken in the following order:—

Hot weather work.	Cold weather work.
1. Kotgarh } Simla District. 2. Kot Khái }	1. Morni, Umballa District. 2. Shahpur Kandi Gurdáspur District. 3. Hamirpur 4. Dera 5. Pálampur (part) } Kángra District. 6. Kángra (part) 7. Núrpur 8. Hills of Hoshiárpur District.
3. Kullu with Seoraj 4. Pálampur (part) } Kángra District. 5. Kángra (part)	

12. The establishment required for plotting the *mauza* and *tikka* sheets will be provided on receipt of an application from you. It will be convenient if an application can be sent in September of each year, giving an estimate of the provision probably necessary during the next Financial year (commencing 1st April). The application should include the cost of the ruled sheets for plotting.

250. About 300 square miles of country was thus partially* triangulated and traversed by the end of April when the party changed its ground in order to carry out the programme arranged for the hot weather months in the higher hills. In this part of the operations, triangulation was carried on in Sheets 310 and 332, covering 308 square miles of country for detail surveying on the 2-inch scale in the Native States of Mandi, Suket, Kumhársain, and Bashahr, and 238 square miles for the 4-inch scale; besides some minor triangulation and traversing required for fixing the positions of tri-junction pillars in Kullu and Kotgarh. This being the first season, no detail survey could be undertaken, as the ground had to be first laid out with trigonometrical points.

251. The demarcation marks in the tracts which came under survey were found to be in good state of repair, but the surveyors found great difficulty in ascertaining the names pertaining to the different *tikka* tri-junctions. This was partly due to the absence of maps showing these boundaries, and partly to the tardiness of the village officials in attending on the surveyors.

252. In accordance with arrangements proposed by Colonel Wace, the party will operate in the following localities during the current field season:—Kotgarh and the Morni *taluka*, for 4-inch detail survey; Kot Khái, for triangulation and traverse preparatory to 4-inch detail survey; Shahpur Kandi (in the Gurdáspur District), for triangulation and traverse; Native States adjoining Kotgarh and Kot Khái, for 2-inch detail survey.

253. As regards Himalayan geography, nothing special was undertaken by the party during the year under review; but while the Tibet Mission was awaiting

* Equal to 150 square miles of completed work.

orders at Darjeeling, the explorer R.—N. returned from Bhután, and Colonel Tanner took advantage of the opportunity and leisure afforded him to examine the whole of the route he traversed which will make an important contribution to the basis on which to compile Sheet No. 7 of the North-East Trans-frontier Series. At the same time Colonel Tanner made arrangements for utilizing further information as to the geography of Tibet brought in by Lama U. G. and a Tibetan who accompanied the man that had been sent some years ago by the late Captain Harman to float timber down the Sanpo,* but of whom nothing had been heard since.

254. Owing to the inexperience of the hands in the novel character of the field-work, as well as to the changes in the *modus operandi* of the same, and to the other varied occupations of the party, no cost-rates can be deduced. The total cost of the party for the year amounted to ₹52,529.†

UPPER BURMA PARTY.

255. Early in the year 1886, after the military occupation of Upper Burma, a survey party was asked for by the Military Department to undertake a reconnaissance survey of the country round Mandalay and to collect and compile the numerous reconnaissance sketches which had been executed by officers attached to the army, of the country traversed by the troops.

Personnel.

Captain J. R. Hobday, S.C., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. T. M. Kennedy, Assistant Surveyor, 2nd grade, from 1st July 1886.

Sub-surveyors.

Mr. J. F. McCollough, from 6th August 1886.
Ahmad Sayad, from 16th April to 17th July 1886.
Faida Ali, from 1st May 1886.
Gobardhun Dass and Shiv Charan, from 11th September.

256. As all the survey parties were at that time engaged in their several field operations, the services of a topographical party could not be then given. The Coast Triangulation Party, however, which was employed under Mr. E. C. Ryall, on the coast of Madras, was offered to commence the trigonometrical work in Upper Burma at once, and the Andaman Party was promised to follow in October when it was expected that the survey of those islands and all the mapping and records connected therewith would be completed.

257. The Military authorities, however, considered that the triangulation party would be of little use this season and urged the immediate despatch of a competent officer with a small staff, who would suffice for the present requirements. This proposal was acceded to, and Captain Hobday, who was in charge of the Andaman Party, was by special request of the Military authorities selected for this duty.

258. Captain Hobday left Port Blair on the 8th March with a small establishment from the Andaman Party, which was subsequently increased by additions from the Burma Topographical Party, and arrived at Mandalay on 2nd April 1886. During the month of April he completed the preliminary triangulation for the survey of the city of Mandalay, determined the latitude and longitude thereof astronomically, and ascertained the elevation barometrically by simultaneous observations at Mandalay and Rangoon. A preliminary map of the country round Mandalay on the scale of 2 miles=1 inch was compiled from the reconnaissances done by officers with the Burma Field Force and submitted to Calcutta for publication.

259. In May, Captain Hobday and Sub-surveyor Ahmad Sayad accompanied the Military expedition to the Kachin Hills, south-east of Bhamo, and surveyed an area of about 150 square miles on the ½-inch scale. A much larger area would have resulted and a coveted view into Yunnan obtained had not the force been stopped after ascending the first spur of the hills.

260. At the end of June Captain Hobday accompanied an expedition to the south-east of Mandalay, taking Ahmad Sayad with him. The triangulation was thus extended southward as far as latitude 21°, when Captain Hobday returned and the Sub-surveyor was left to carry on the detail survey from the

* To ascertain its identity with the Brahmaputra or Irrawaddy.
† The Officer in charge reports favourably of all his assistants.

post of Kyouksé. On 17th July Ahmad Sayad, while at work, was attacked by Shan dacoits, some 8 miles east of Kyouksé, and being wounded by a bullet, was overtaken and killed; the escort and menials managed to effect their escape. The loss of this promising Sub-surveyor is much regretted.

261. During the rains, the establishment was further strengthened by an Assistant Surveyor and 3 Sub-surveyors. The opportunity of a telegraph party being sent to lay out a line from Mandalay to Bhamo was availed of to attach an assistant, Mr. Kennedy, to extend the triangulation and topography northwards up the Irrawaddy. From July to the end of September Captain Hobday was engaged in compiling a general map of the country on the $\frac{1}{4}$-inch scale between the parallels of 19° and 26° N. latitude and the meridians of 94° and 98° E. longitude. This is comprised in 14 sheets and is based on the various maps, routes and sketches lately obtained from all sources and on local information supplied by the natives of the country. These sheets were reproduced as soon as they were received in the head-quarter office, Calcutta, and a large number of copies have been supplied for the use of the troops now operating in Upper Burma.

262. During this period, portions of the establishment were engaged, as the weather permitted, on the survey of the City of Mandalay, on the 6-inch scale and on the extension of the Mandalay triangulation southwards.

263. The city survey, which covers an area of about 50 square miles, has been completed. This work was much impeded by the inundation of the country caused by the bursting, on 16th August, of the embankment which surrounds the city. A sketch map of the new cantonment site at Bhamo on the scale of 12 inches=1 mile was also executed. The total area triangulated during the period under review amounts to about 5,200 square miles.

264. The amount of work that has been effected by Captain Hobday and his small staff is highly creditable, and their services have been most favourably acknowledged by the Chief Commissioner of Burma, who has intimated that Captain Hobday's work has been of the greatest value to the Military and Civil authorities, and that his industry has been remarkable.

265. It had been arranged to commence a regular survey of the new province during the current season with two topographical parties, working up the Irrawaddy and Sittang Valleys, but as it was found that the country was in too disturbed a state for systematic survey operations to be carried on without risk, it was determined to defer this programme and to retain the services of Captain Hobday and his small staff for military reconnaissances. The party has now been strengthened up to the complement of an ordinary topographical party, so that the opportunities afforded by the movements of the troops, on which the survey operations depend almost entirely at present, may be utilized to the full to obtain as much additional geographical information of the country as possible, and Captain Hobday's object during the current season will be to attach survey officers to the different expeditions. Another small party under Colonel Woodthorpe, R.E., will operate with the column under General J. J. Gordon, C.B., advancing into the Chindwin Valley from Manipur, and it is hoped that the triangulation executed by Captain Hobday, which is at present "*en l'air*," may thus be connected with the main triangulation of India, and a more satisfactory knowledge of the geodesy of Upper Burma arrived at.

TRANS-HIMALAYAN EXPLORATIONS.

266. The explorer M—H, who had just returned to India when the last Report was sent in (see page 79 of Annual Report for 1884-85), has furnished information along the route from Dagmára Thana (in the Bhágalpur District) along the Dádhkosi to Dingri in Tibet; thence westwards *viâ* the Pálguchho Lake to Jongkhajong; then southwards *viâ* Kirong and the Tirsúli River to Arughát on the Búri Gunduk; and from the last-named place northwards to Nubri, and southwards down the Naráini to Tribeni. Thus he has furnished 400 miles of entirely new traverse besides confirming the details of 100 miles of ground previously travelled over. It is a great pity that the explorer brought back no determinations of height which would have been most interesting, for he crossed the main ridge of the Himalayas by one of the highest passes (the

Pángula), 24 miles west-north-west of Mount Everest, his route actually approaching that peak within 15 miles.

267. Another explorer, R—N, was despatched, in October 1885, to start from Darjeeling across Bhután and the mountains to the east, and to reach Gyala Sindong, the lowest point yet reached on the Sanpo; and starting from the left bank of the river to find his way back to India by *any* practicable route *without re-crossing the river*. The object of this was to set at rest the *vexata quæstio* as to whether the Brahmaputra or the Irrawaddy was the recipient of the waters of the Sanpo. The explorer met with bad luck at first from the fact of there being at the time a great dispute between Tibet and Bhutan, in consequence of which all the passes into Tibet were closed. He therefore had to find his way back to India down the Hachhu and Wongchhu rivers to Baxa, having been detained and kept under surveillance for ten days by the *jongpon* of Chukhajong. His next attempt was made from Dewangiri, whence he proceeded by a pretty direct route to the Monlakachung Pass and thence to Suphuk cave about 8 miles south-west of Seh, a very large monastery on the Lhobrak River, a value of the position of which had been previously obtained from the north by Lama U—G's traverse referred to in the Annual Report for 1883-84. Here, in consequence of the rumours regarding the advance of the Tibet mission from the south and of a party of Russians from the north, the officials absolutely stopped his further progress and kept him in custody for nine days and then conveyed his party under escort to Seh. From here he managed to escape during the night with his party and, keeping away from the routes usually followed, found his way to Menchuna (lat. 28° long. 92°), and thence *vid* Tawang to Odalguri (along the route formerly traversed by Pundit Nain Sing). The work, which furnishes about 280 miles of new route survey, is valuable so far as it goes, inasmuch as it opens up the general geography of Bhutan and forms a connection with the work of Pemberton, (1838) from the south, and of the Pundit and the Lama from the north.

Neither the reports nor the maps are yet ready for publication.

TIDAL AND LEVELLING OPERATIONS.

268. The direction of these operations remained in the hands of Major Baird until the 20th January 1886, when, having been appointed to officiate as Master of the Calcutta Mint, he was relieved by Major Hill, who had joined the party with that object on the 29th of the preceding month.

Personnel.

Major A. W. Baird, R.E., F.R.S., Deputy Superintendent, 3rd grade, in charge till 20th January 1886.
Major J. Hill, R.E., Officiating Deputy Superintendent, 2nd grade, in charge from 20th January 1886.
Lieutenant F. B. Longe, R.E., Officiating Deputy Superintendent, 4th grade, joined the party on 23rd October 1885, transferred to South Maratha Survey on 21st December 1885.
Mr. G. Belcham, Surveyor, 3rd grade.
" E. J. Connor, do. 4th do.
" H. Corkery, B.A., L.L.B., Assistant Surveyor, 1st grade.
" P. F. Prunty, Assistant Surveyor, 1st grade, transferred, 1st September 1886.
Sub-surveyor Narsing Das.
" Dhondu Venayak; 1 watch-maker, and 18 recorders and computers.

TIDAL OPERATIONS.

269. The recording of the tidal curves by the self-registering tide-gauges, their reduction, and the publication of tables of predicted heights, have been continued during the year as usual. Of the 16 observatories, which were in operation at the end of the last year, 3 have been closed during the year under report, on completion of the usual period of registration, *viz.*:—Diamond Harbour, Amherst and Moulmein, the period having been extended indeed to six years in the case of Moulmein, owing to certain peculiarities in the tides of that port. Four new observatories have been started during the year, *viz.*:—Cochin, Cocanada, Chittagong and Bhávnagar,—the instrumental equipment for the first three having been obtained from the observatories of Beypore, Vizagapatam and Moulmein respectively, and that for Bhávnagar having been provided, as stated in last year's report, by the Durbar of that place. The

instruments set free by the closing of the Amherst Observatory are intended to be employed at Akyab so soon as the arrangements for establishing a tidal observatory there can be made. The 17 observatories, which are now in regular work, with the dates of commencement, are here given :—

Aden	3rd	March	1878
*Kurrachee	1st	May	1881
Bhávnagar	1st	January	1886
Bombay	1st	January	1878
Mormugão (Goa)	16th	March	1884
Cochin	25th	January	1886
Colombo	1st	February	1884
Galle	1st	April	1884
Negapatam	6th	December	1881
Madras	1st	February	1880
Cocanada	1st	April	1886
Dublat (Saugor Island)	22nd	April	1881
Kidderpore	22nd	March	1881
Chittagong	6th	June	1886
Elephant Point (new site)	1st	January	1884
Rangoon	1st	March	1880
Port Blair	19th	April	1880

270. In order to present the scheme of tidal operations in a connected form, it appears desirable to give below a list of the observatories which have been closed on the completion of their registration since they were systematically established in 1877, prior to which year the only observations taken by the Survey Department were those in 1873—75 at Okhá, Hanstal and Nowanar (Navánar) in the Gulf of Cutch :—

Pámban	closed	28th	December	1882
Kárwár	do.	14th	April	1883
Beypore	do.	14th	March	1885
Vizagapatam	do.	30th	March	1885
False Point	destroyed by cyclone	22nd	September	1885
Diamond Harbour	closed	12th	April	1886
Moulmein	do.	24th	April	1886
Amherst	do.		October	1886

271. The stations at which the establishment of new tidal observatories is contemplated are Akyab, Diamond Island at the mouth of the Bassein river, and Tuticorin. It may be mentioned here that the ordinary period over which observations have to be taken, is five years, but in the case of permanent observatories, such as Aden, Bombay, &c., this period may be extended indefinitely.

272. All the observatories, with the exception of Cochin and Cocanada (only recently established) and of Kurrachee and Port Blair, have been inspected during the past year either by the officer in charge of the party, or by one of his assistants ; that at Aden having been inspected last August by Major Hill on his way to India when returning from leave.

273. The usual account of the working of each observatory will be found in the appendix. Owing to the causes mentioned in paragraph 282 of the last Annual Report, it was unfortunately found necessary to reject the registrations at Negapatam for the period 6th December 1883 to 20th December 1885; at Madras, owing to the bottom of the float-box giving way, no registrations were secured for a period of three weeks ; and at Rangoon, in consequence of the upsetting of the tide-gauge by the steamer *Zephyr*, there is a break in the diagrams from 24th June to 5th July ; otherwise the observatories have worked satisfactorily, excepting, of course, the usual trivial interruptions. An exceptional and interesting tidal disturbance is reported from Mormugáo.

274. The reductions of the observations have made very good progress during the year, considering the increased labor of computation consequent on breaks in the tidal registrations as above mentioned. The observations at 13 ports have been reduced, and the tabulated values of the tidal constants and the discussion of the results, will be found in detail in the appendix.

275. The usual work in connection with the timely issue of the Tide Tables for 1887 has been satisfactorily got through. These tables will contain the

* The tidal observations prior to 1881 which have been used in combination with the above in calculating the Tide Tables for this port were taken by Messrs. Parkes and Price.

predictions of the heights and times of high and low water for 23 ports. For the first time, the heights in these tables have in the case of 11 of the ports been referred to a scientific datum which has been adopted after discussion with Professor Darwin and Captain Wharton, R.N., Hydrographer to the Admiralty. This new datum is termed "The Indian spring low-water mark," and it will be the *final* datum for all tidal observatories, except where special reasons or local considerations exist for retaining another datum; the latter will, however, not be materially different from the former, and will always be capable of reference thereto, as the difference of height will in each case be carefully ascertained.

276. The predictions for 1885 may be summarised as follows:—

Percentage of predictions within 15 minutes of actuals.

	High water. Per cent.	Low water. Per cent.
Open coast stations	70	67
Riverain "	61	53

Percentage of predictions within 8 inches in height of actuals.

	High water. Per cent.	Low water. Per cent.
Open coast stations	93	92
Riverain "	60	54

277. These percentages are all lower than those for 1884; but an examination of the detailed lists of comparisons given in the appendix will show that the comparative differences would be reduced by more than 4 per cent. if the results at Negapatam and Elephant Point were not included therein.

LEVELLING OPERATIONS.

278. During the year under report, another very satisfactory out-turn of spirit-levelling has been obtained, amounting to 526 miles of double levelling, in the course of which the heights of 394 permanent bench-marks and of 24 Trigonometrical Survey stations have been determined. It consists of main lines as follows:—(1) along the railway line from Madras tidal station *viâ* Tanjore to the tidal station of Negapatam; (2) from Tanjore *viâ* Ramnad to the tidal station of Pámban; (3) from Ramnad to Tuticorin tidal station; with the usual branch lines for connecting with stations of the Trigonometrical Survey, &c. Assuming the heights of the mean sea-level to be identical at the tidal stations above named, the generated errors of levelling in the three sections are ·0021 feet, ·0019 feet, and ·0013 feet per mile; or if the error be calculated between the extremities of the line, it is represented by only ·0004 feet per mile. Pairs of test bench-marks, for detection of secular change of relative level between the land and the sea by periodic determinations thereof, have been embedded on suitable sites in the vicinity of Negapatam, Pámban, and Tuticorin tidal observatories, and connected therewith.

279. Confidence being wanting in the heights of the South Konkan Series, determined over 40 years ago, without precautions having been taken for overcoming the uncertainties of terrestrial refraction, especially necessary in this case, where one flank of the series rests on the elevated *ghâts* and the other skirts the sea coast, a revision was considered a *desideratum* before their incorporation in the Professional Volumes. These heights have all been revised by trigonometrical levelling; and on account of the uncertain refraction on rays between the top of the *ghâts* and the sea coast, *simultaneous* reciprocal observations were taken on such rays in order to reduce error from refraction to a minimum; the resulting heights may therefore be accepted as exceptionally accurate and probably true to within 2 or 3 feet. A comparison between the new heights and the old exhibits discrepancies with a range of 43 feet. The revision may therefore be considered to be fully justified by the result. As one of the southernmost stations of this series is in the immediate vicinity of Mormugáo tidal station, a short line of spirit-levels will be run to it in the coming season, and a comparison with the value as brought down by the trigonometrical levelling will furnish the means for dispersing any small residual error that there may be in the latter. Opportunity was taken

to protect all the principal stations observed at, and to hand them over for safe custody to local native officials.

280. The extracts from Major Hill's narrative report will be found at page xix of the appendix.*

GEODETIC.

LATITUDE OPERATIONS.

281. These operations were suspended during the year under review, as there are only two Astronomical Parties, and these were both engaged, on the Telegraphic Longitude operations, but as explained in paragraph 295, page 59, of last year's Report, no comment could be made on the results of the Latitude operations during 1884-85, conducted by Major Heaviside, R.E. These results are now given in tabular form and will be found, together with extracts from that officer's report, at p. lviii of the appendix.

282. There being only one officer, Lieutenant S. G. Burrard, R.E., available for astronomical work during the current field season, the Longitude operations have been suspended and the Latitude observations have been resumed, and are being continued on meridian 80° southwards from Sarandi Pát Station, Latitude 22¼°. Major Heaviside closed work in 1885 at Potenda Station, having worked on practically the same meridian from north to south over about 4° of latitude. On the arc of 1½° between Potenda and Sarandi Pát, there are already two stations at which Latitude observations were taken some years previously. The present intention is to have a series of Latitude stations on or near meridian 80° from the Himalayas to Madras, embracing nearly 15½° of latitude.

ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

(ASTRONOMICAL, PARTIES Nos. 1 & 2.)

283. These operations were continued during the past season, nine arcs having been measured — the largest number yet completed in one season—and, besides these, observations were taken on an experimental arc at Dehra Dun, the necessity for which, and the results obtained will be detailed below. The two Astronomical Parties were engaged in these operations.

284. As explained in paragraph 247, page 55 of the General Report for 1883-84, the two transit instruments were sent to England at the close of the field season of that year, to be examined by the makers and to have certain defects, if possible, remedied. Major G. Strahan, who was on furlough, was invited to inspect the instruments when the makers should report their work complete. Major Strahan was detained in England for six months on duty, in extension of his furlough, for this work, which he carried out in the enclosure of the Observatory at Greenwich. Here, through the kindness of the Astronomer Royal, a site was placed at his disposal and shelter afforded for the telescopes and chronograph, as well as an electric communication with the standard sidereal clock, and assistance of all kinds was received from Mr. Christie and his co-adjutors, which Major Strahan gratefully acknowledges. He completed his task in time to admit of the instruments being sent out to India for the resumption of operations at the commencement of the field season

PERSONNEL.

No. 1 Astronomical Party.

Major W. J. Heaviside, R.E., Deputy Superintendent, 2nd grade, in charge up to January 24th, 1886.
Lieutenant S. G. Burrard, R.E., Assistant Superintendent, 1st grade, from January 24th, 1886.
Mr. W. W. MacNair, Surveyor, 3rd grade, Sub-surveyor, Dhondu, Bulwant, Jhoshi.

No. 2 Astronomical Party.

Major G. Strahan, R.E., Deputy Superintendent, 1st grade, in charge.
Babu Harsahai.

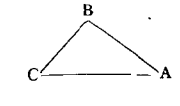
*Major Hill reports very favourably of Messrs. Belcham, Connor, Corkery, and Prunty, and also of his native assistants, making special mention of Ganesh Sadasheo, a most promising Sub-surveyor, who, after eight years' good service, died during the past season from an illness brought on by exposure.

under review.* Colonel Haig, the Officiating Deputy Surveyor General, in charge Trigonometrical Branch, reported however, to the Surveyor General that while having all confidence in the completeness and excellency of the makers' work, and in the ability of Major Strahan to satisfy himself of the same, nevertheless he was not enabled by Major Strahan's careful and elaborate report to pronounce decidedly as to the fact of the defects having been remedied. On this account Colonel Haig, with the Surveyor General's concurrence, went to Agra, where the operations were to commence, and there, after consultation with Major Heaviside, decided on having the series of experimental observations taken, which were mentioned in paragraph 295, page 59 of last Annual Report. These observations afforded the strongest reasons for considering the instrumental defects to have been completely removed, and the regular operations were at once resumed. The behaviour of the instruments throughout the season was such as to give every confidence in their perfection; yet, strange to say, when the results came to be reduced and compared in the recess season, it was found that there was still a mysterious source of very appreciable error; and, in spite of all the thought and care bestowed on the subject by the executive officers and the Superintendent of the Trigonometrical Branch, it remains undiscovered.

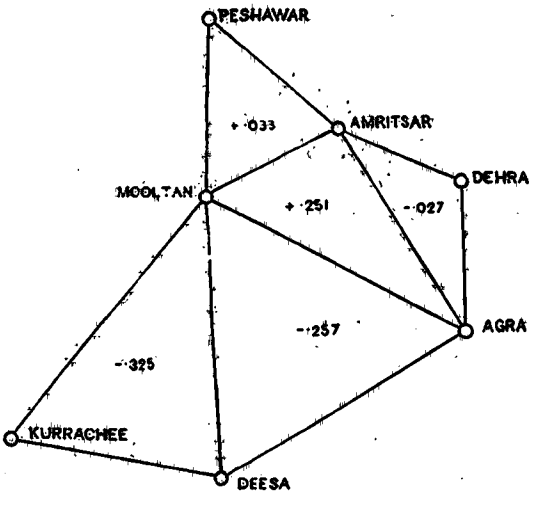
285. Out of five verificatory circuits,† three exhibit large errors between a quarter and a third of a second of time. If the theoretical probable error of each arc were determined separately from the small discrepancies between the many measures obtained for the arc by the system of simultaneous observations at each end on several nights to between 20 and 30 stars, it would, in any case, not exceed one hundredth of a second of time; so that we have to deal with the phenomenon of errors as large as $0^s{\cdot}33$ appearing in the combination of three arcs, the theoretical probable errors of which, if added together, would not exceed $0^s{\cdot}03$; and we have also the experimental arc at Dehra Dun (the two ends o fwhich were only a few yards apart, and one due north of the other), proving that there may be an error of $0^s{\cdot}18$ in a single arc, the accordant measures of which would give a theoretical probable error of $0^s{\cdot}01$. Large circuit errors have occurred before, and have occasioned the re-measurement of three arcs, the theoretical errors of which were also very small, but then it was thought that the cause lay in an instability in the relations between the visual and rotatory axes of the telescopes, due to a weakness in the joints between the three parts, which was thought to have been detected; but in the present instance, all the experiments that have been made specially for the purpose, have failed to show up any such instability. This mysterious source of error tends to throw suspicion on the accuracy of all the arcs hitherto measured, because that accuracy is assumed on the evidence of the small probable error of each arc and the small circuit errors; but it has now been demonstrated that there may be in a single arc an error, out of all proportion with the probable error and larger than most of the accepted errors of circuits of three arcs combined, and therefore that a circuit which apparently closes well, *i.e.*, with a small circuit error, may have in each of its component arcs an error possibly in excess of the circuit error which may be fortuitously small owing to the arc errors not having the same sign. Hence it is considered imperatively necessary to make, on the Dehra Dun experimental arc, a further and exhaustive series of experiments, in the course of which there

* The work of the makers consisted in the construction of new bearings or Ys of a different kind from the original; the complete overhauling of all the parts of the telescopes leading to the removal of the micrometer screws, which were thought to be faulty; the introduction of new ones, and the providing of a new Bohnenberger eye-piece to one of the telescopes in place of one of lower power, in order that the optical powers of both instruments should be similar, which before was not the case: besides other minor alterations. The original bearings were of a novel pattern and self-adjusting, each accommodating itself to its pivot, and therefore to the common axis of rotation by means of a universal joint, advantage of which was taken to give the bearing surfaces a hollow cylindrical form so as to fit the pivots and receive the weight of the telescope distributed over four surfaces (two to each bearing), about $1\frac{1}{8}$ square inches each: in the ordinary Y pattern the surfaces are slightly convex, and so require no very exact adjustment to the axis of rotation, but the weight of the telescope is received on four *points* (two to each Y), which of course, get worn by work. The original bearings were very beautifully made, but as it was suspected that they might afford shelter to a hidden source of error, additional new Ys of the ordinary pattern were supplied and were used through the past season and in all the experimental observations.

† Any three arcs forming a triangle offers a verificatory circuit: thus, the sum of the arcs A B and B C is equal to the arc A C: therefore, if the sum of the *measured* arcs A B and B C differs from the *measured* arc A C the difference is due to error of measurement in one, two, or all three arcs.



shall be every possible interchange of observers, telescopes, electrical apparatus, clocks and stations. A programme for these experiments has been arranged by Colonel Haig, and it is intended to carry them out during the current field season by slightly curtailing the Latitude operations and bringing the Astronomical Parties to Dehra Dun in March, in order that a recess season may intervene between the observations, and the subsequent resumption of the regular Longitude operations. In this way time will be afforded for a patient investigation of all the results of the experiments, and the chance of the mysterious source of error escaping detection will be reduced to a minimum. It may be regretted that the observations on the experimental arc were not extended last season according to the present project, but the existence of such error as has now been shown up was never suspected or thought possible, and the arc was measured for the purpose of establishing the extreme accuracy with which the operations might be credited. It is hoped that the cause of error will be discovered, and that all the steps taken in the discovery, including the experimental observations at Greenwich and Agra, will afford an interesting chapter for the next Annual Report.



286. The nine arcs measured during the past season are shown in the accompanying diagram, combined with the two arcs Agra-Deesa and Deesa-Kurtachee previously measured, but here included to present the circuit errors, which are printed within each triangle or circuit.

Summary of the Out-turn of field work of the Parties of the

Scale of Survey.	Name and *locale* of Field Operations.	Triangulation.					Secondary—in which each angle is usually observed on two zeros.					Tertiary—in which two angles of each triangle are observed.				Number of extra heights determined.	
		Instrument used.	Area triangulated in square miles.	Number of Stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Number of Stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.		
Trigonometrical	Coast (Godávari and Kistna Districts).	12″	378	94	3·5	3·6	101 (*a*)	95	5	0·1	100	7	14	0·2	6	...	1
	Spirit Levelling (Madras)	Spirit levels	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Trigonometrical Levelling (South Konkan).	14″	...	19	...	...	...	...	...	...	...	...	...	...	...	...	
26·4 inches = 1 mile	Baroda City	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
16 inches=1 mile	Ajmere	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5
	Akyab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Basti	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Bilaspur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Gorakhpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Jubbulpore and Damoh	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10
	Kámrúp	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Mozufferpore	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Raipur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Sambalpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
8 inches=1 mile	S. Marátha (Belgaum Forests)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15
6 inches=1 mile	Mandalay City	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
4 inches=1 mile	Andaman (Port Blair)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Basti	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Burma (reserved Forests)	8″, 6″, 5″	263	21	12	12	6	10	17	0·5	6	12	19	0·6	12	88	
	Himalaya (Kángra and Simla Hill States).	5″ and 12″	688	123	1·0	1·7	123	157	12	0·4	44	420	740	0·9	278	2	20
	Himalaya (Nepal Boundary, Mechi River).	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
2 inches=1 mile	Baluchistan	6″	740	39	4·2	5·0	42	86	11	0·6	34	146	249	0·8	130	...	
	Burma (unreserved Forests)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Cutch	5″	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Deccan	12″ and 6″	568	31	7	18	13	56	15	0·7	12	58	116	1·5	...	12	25
	Gujarát	7″, 6″, 5″	749	50	2·7	4·7	26	83	4·7	0·30	31	230	399	0·8	132	...	
	Himalaya (Kángra and Simla Hill States).	7″	308	17	4	4·3	17	48	12	0·3	16	58	98	1·3	55	...	
	Mirzapur	6″	194	15	2·6	11	13	43	21	0·3	12	63	110	0·4	5	...	
	Punjab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	South Marátha	5″	1,210	144	3·85	4·15	144	200	14·3	0·54	144	193	399	1·16	162	14	30
1-inch=1 mile	Mysore	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Rajputana (Jodhpore and Pálanpur)	8″	1,040	24	5·2	7·7	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	
inch=1 mile	Andaman	6″	955	18	16·2	64	14	26	4	1·7	5	49	69	4·1	11	...	
	Baluchistan	...	4,350	20	38	40	23	35	11	0·3	20	88	131	0·7	80	...	
	Rajputana (Jodhpore)	7″ and 12″	4,810	108	12	18	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	35
Reconnaissance. ½-inch and ¼-inch	Baluchistan, N.-W. Frontier	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
¼-inch	Upper Burma	...	5,200	...	...	...	...	...	...	...	...	...	...	...	...	...	37

Survey of India Department during the year 1885-86.

	SPIRIT-LEVELLING OPERATIONS.				TRAVERSING.					TOPOGRAPHY.						REMARKS.
	Number of miles levelled over.	Number of permanent bench-mark stones embedded.	Number of Trigonometrical Stations connected with lines of level.	Number of other permanent points fixed as bench-marks.	Number of stations at which theodolite was set up.	Linear miles.	Average angular error per station in seconds.	Average error per 1,000 links in links.	Square miles, main circuit and boundary survey.	Area completed during the season in square miles.	Average number of plane-table fixings per square mile.	Number of linear miles of test line.	Number of villages.	Number of fields.	Average size of fields in acres.	
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	(*a*) Observations taken on 4 zeros.
	526	51	24	343	...	...	...	...	...	...	...	...	...	...	...	
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	...	...	...	...	...	...	...	...	...	6·2	...	39	...	...	...	
5	...	...	...	...	2,638	656	...	...	243	...	...	...	57	...	...	
	...	...	...	...	(*b*)	(*b*)	1·5	·1	794	661	...	...	337	694,056	0·29	(*b*) Not tabulated.
	...	...	...	...	17,940	3,739	3	·1	782	783	...	2,216	2,276	1,126,230	0·44	
	...	...	...	...	18,622	6,264	2	·3	1,793	763	...	1,524	751	474,296	1·03	
	...	...	...	...	18,339	3,306	2	·1	1,025	820	...	1,712	1,251	894,028	0·58	
10	...	...	...	...	41,949	6,380	2	·3	2,215	...	...	...	1,383	...	..	
	...	...	...	...	7,770	1,722	3	·1	481	468	...	1,058	319	147,818	2·03	
	...	...	...	...	(*b*)	(*b*)	2	·1	803	414	...	...	656	582,200	0·45	
	...	...	...	...	(*b*)	5,958	5	·5	2,169	...	...	...	1,117	...	...	
	...	...	...	...	(*b*)	(*b*)	2	·4	885	...	...	...	436	...	...	
15	...	...	...	...	1,593	152	...	...	6	...	...	...	...	...	...	
	...	...	...	...	...	...	...	...	...	59	...	...	...	...	...	
	...	...	...	...	...	...	...	...	...	28	139	...	...	...	...	
	...	...	...	...	...	...	...	...	...	36(*c*)	...	...	48	...	...	(*c*) Riverain.
	...	...	...	...	8,099	507	6	4·1	...	199	201	28·8	...	...	...	
20	...	...	...	...	405	99	18	2·4	...	...	...	...	...	...	...	
	...	...	...	...	...	24	...	...	...	...	...	...	...	...	...	
	...	...	...	...	...	...	...	...	...	620	2·3	138	...	...	...	
	...	...	...	...	...	...	...	...	...	131	90	...	...	...	...	
	...	...	...	...	1,132	449	9·4	1·4	...	3,805	6	303	...	...	...	
25	...	...	...	...	2,360	650	1·8	0·6	...	1,676	20·5	14	...	...	...	
	...	...	...	...	2,585	422	16	1·1	...	2,524	22·5	470	...	...	...	
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	...	...	...	...	6,599	1,211	4·5	0·01	...	487	37	*in situ*	...	...	...	
	...	...	...	...	(*b*)	8,076	·8	...	3,770	2,624(*d*)	...	4,030	...	...	...	(*d*) Area tested only, and the maps compiled from the Patwari Survey.
30	...	...	...	...	3,231	1,164	7	0·6	...	1,672	...	124	...	...	...	
	...	...	...	...	...	...	...	...	...	2,570	9·6	207	...	...	...	
	...	...	...	...	...	...	...	...	...	256	6·3	17	...	...	...	
	...	...	...	...	...	...	...	...	...	1,464	2·1	*in situ*	...	...	...	(*e*) Work not computed.
	...	...	...	...	...	...	...	...	...	514	1·4	...	...	...	...	
35	...	...	...	...	...	...	...	...	...	3,540	2·7	157	...	...	...	
	...	...	...	...	...	...	...	...	...	30,000	...	...	...	...	...	
37	...	...	...	...	...	...	...	...	...	150	...	...	...	...	...	

Statement showing the Cost-rates of work executed by the several Field

Names and *locale* of Field Parties.	Cost-rate per square mile in Rupees.							Rate in annas for traverse and detail and preparation of Maps.	
	Triangulation.	Traversing.	Detail Survey on scales of					Scale 16″=1 mile.	
			1/2″	1″	2″	4″	16″	Per acre.	Per field.
								a. p.	a. p.
Topographical Surveys.									
Andaman	7·0	...	8·9	...	...	276·6	...	...	...
Baluchistan	0·5	...	11·4	...	149·1	...	...	...	...
Cutch	...	22·6(*a*)	...	...	12·3	...	...	...	...
Deccan	11·7	6·9	...	...	22·4	...	...	...	...
Gujarat	...	2·5(*a*)	...	...	16·9	...	...	...	...
Mirzapur	7·6	10·8(*a*)	...	...	68 7	...	...	...	...
Mysore	...	...	...	22·1	...	...	...	...	...
Rajputana	3·3	...	2·9	20·9	...	...	...	...	...
South Maratha	13·3	3·7	...	...	13·4	...	...	...	...
Forest Surveys.									
Lower Burma	37·2	129·4	...	...	102·8	220·4	...	...	...
Traverse Surveys.									
Ajmere	...	46·2	...	...	...	...	...	...	...
Jubbulpore	...	31·8	...	...	...	...	...	...	...
Punjab	...	9·4(*b*)	...	...	9·2(*c*)	...	...	...	...
Raipur	...	32·5	...	...	...	...	...	...	...
Sambalpur	...	36·0	...	...	...	...	...	...	...
Cadastral Surveys.									
Akyab	...	60·2	...	...	...	...	183·9	6 4	1 10
Basti	...	22·6	...	...	...	...	83·4	2 7	1 2
Bilaspur	...	16·1	...	...	...	...	70·1	2 2	2 3
Gorakhpur	...	20·5	...	...	...	...	70·5	2 3	1 4
Kamrup	...	33·4	...	...	...	...	94·2	3 3	6 7
Mozufferpore	...	28·8	...	...	...	...	97·1	3 2	1 5
Trigonometrical Surveys.									
Astronomical Parties, Nos. 1 and 2	...	...	...	...	...	...	...	...	...
Coast (Godáveri and Kistna Districts)	...	...	...	...	...	...	...	...	...
Himalaya	(*s*)	(*s*)	...	...	...	...	...	...	...
Tidal and Levelling Operations	...	...	...	...	...	...	...	...	...

Parties of the Survey of India Department during the year 1885-86.

Cost-rates.					Total cost of Party.	Remarks.
Stone embedding.	Records (Khanapuri.)		Completion of Nagri &c., Records, Assessment, Statistics, &c.			
Per square mile.	Per square mile.	Per field.	Per square mile.	Per field.		
₹	₹	a. p.	₹	a. p.		
...	...	...	...	...	27,540	(a) Per linear mile.
...	...	...	...	...	1,03,633(d)	(b) Traversing limited to fixing village trijunction boundary marks.
...	...	...	...	...	53,753	(c) Topography not surveyed, but obtained by reduction from Settlement Survey Maps: the reduced maps are tested.
...	...	...	...	...	50,924	
...	...	...	...	...	58,078 (e)	(d) Includes ₹2,388 for Nushki Explorations.
...	...	...	...	...	55,243(f)	(e) ,, ₹12,312 for Baroda City Survey and ₹3,191 for Baroda State Boundary Surveys.
...	...	...	...	...	57,005	(f) Includes ₹7,685 expended on Dudhi survey.
...	...	...	...	...	45,875(g)	(g) ,, ₹11,000 expended on Ajmere-Merwara Revision Survey.
...	...	...	...	...	54,817 (h)	(h) Includes ₹1,695 expended on mapping of 4" sheets of District Thana and ₹5,861 expended on Forest Survey on 8" scale.
...	...	...	...	...	1,15,138(i)	(i) Includes ₹3,300 for purchase of elephants and ₹90 demarcation expenses.
...	...	...	...	...	11,247	(k) Includes ₹1,384 expended on Kashmir and Sialkot Boundary Survey and ₹370 on plotting traverse sheets for Hissar Settlement Survey.
2·5	...	...	...	...	76,012	(l) Includes ₹1,350 expended on Revision Work.
...	...	...	...	...	64,530 (k)	(m) ,, ₹3,505 expended on the completion of Benares records and ₹5,924 on 2" and 4" mapping.
...	...	...	...	...	70 548	(n) Includes cost of transporting the party to Bilaspur (about ₹5,500) and ₹6,763, cost of tent equipment—Rates of first season in a new district.
...	...	...	...	...	31,893	(o) Includes ₹524 expended on completion of Diwara sheets on 4" scale. Includes ₹1,387 expended on survey and mapping of an overlap in District Sarun on 2" scale. Includes ₹2,650 expended on work done elsewhere.
10·2	...	...	...	...	1,78,890 (l)	
3·7	40·5	0 5	47·0	0 6	1,63,723(m)	(p) Includes ₹1,220 expended on Revision Survey and ₹1,748 on 2" mapping.
1·5	82·0	2 2	...	...	1,34,940(n)	(r) Includes ₹4,906 expended on salaries and travelling allowances prior to commencement of operations at Mozufferpore and ₹5,633 cost of tent equipment—Rates of first season in a new district.
10·3	30·5	0 5	38·5	0 7	1,57,986 (o)	
...	68·6	3 5	...	...	95,285(p)	
14·2	59·5	0 8	69·5	0 9	1,23,566 (r)	
						(s) Not deducible.
...	...	...	...	...	52,620	
...	...	...	...	...	30,264	
...	...	...	...	...	52,529	
...	...	...	...	...	60,464	

Tabulated Statement of the principal Records prepared in the several Recess Offices of the Field Parties of the Revenue Branch for the year ending 30th September 1886.

Province and District.	Survey Party.	Mapping.						Traverses.		Field Books.		Area Books.		For Settlement Department.		Remarks.
		Original field Sections.	Cadastral 16-inch sheets.	Sheets 4 inches = 1 mile $7\frac{1}{2}' \times 3\frac{3}{4}'$.	Quarter sheets 2 inches = 1 mile $15' \times 7\frac{1}{2}'$.	Index Maps.	Triangulation Charts.	Main circuit with azimuth computations. Vols.	Village or sub-circuit. Vols.	Main circuit. Vols.	Village or sub-circuit. Vols.	Villages.	Fields.	Sheets or traces.	Village areas or khasras.	
North-West Provinces.						Cadastral Surveys.										
Basti	No. IV	5 on 4″	1,535 on 16″ 49 on 24″ 24 on 32″	10	13	1	...	1 1 Az.	7	1	7	2,276	1,126,230	2,276	2,276	
Gorakhpur	No. V	...	1,447 on 16″	...	...	...	...	1 1 Az.	8	1	14	1,251	894,221	1,251	1,251	
Central Provinces.																
Bilaspur	No. H	...	854	...	...	2	...	2 1 Az.	7	2	7	647	370,569	649	649	
Burma.																
Akyab	No. VII	...	0·5	...	30	...	...	2	4	2	8	337	694,056	337	337	
Assam.																
Kámrúp	No. VI	...	653	...	17	1	...	1 1 Az.	2	1	3	3·9	147,8·8	3·9	3·9	Also 288 Nist Kheraj area statements. 66 Lakhiraj area statements. 2 Waste land Grants. 3 Reserved Forest. 70 Jungle Sections.
Bengal.																
Mozufferpore	No. VIII	...	734	...	...	3	...	1	7	2	15	656	582,200	656	656	
Central Provinces.						Traverse Surveys.										
Jubbulpore and Damoh	No. IX	...	...	...	...	1	...	4	10	6	18	...	...	...	..	
Raipur	No. III	...	...	...	...	...	...	2	5	1	18	...	...	.. (a)	...	(a) Skeleton traverse sheets on the 16″ scale are being furnished for the use of the Settlement Surveys, number not yet known. Copies of village traverse tables are also being furnished. (b) Skeleton traverse sheets. (c) Skeleton traverse sheets of 57 villages. (d) Details obtained by reduction from Settlement Survey maps. (e) Copies of village traverse data. (f) Index charts to traverses.
Sambalpur	Detacht.	...	...	...	...	1	...	1	3	1	9	..	...	735(b)	..	
Rajputana.																
Ajmere	Detacht.	1 on 4″ Forest	...	...	19 (Skeleton Plots)	...	...	...	1	...	2	...	...	266(c)	...	
Punjab.						Topographical Surveys.										
Hoshiárpur	No 1	135 on 2″ (d)	...	...	24	2	...	2	...	1	3	...	...	1,325(e)	33(f)	
Gurdáspur								...	...	1	...	...	...	...	...	
Jullundur								...	...	1	1	...	...	557(e)	2·(f)	
Kapurthala State								1	2	...	...	...	...	...	...	
Ludhiána								...	...	1	2	...	...	424(e)	32(f)	
Umballa								2	...	1	2	...	...	690(e)	17(f)	
Bombay.																
Belgaum, Dhárwár, and Savantvádi State	No. X	21 on 2″	...	6 Forest on 8″	16	...	3	...	1	...	2	...	...	...	...	Vols.
Kolába, Ratnágiri, Sátára and States under Southern Maratha Agency	No. XI	26 on 2″	...	...	14	3 Trav. Charts.	2	...	3	...	4	...	...	...	...	Horizontal Angle Books . 5 Abstract of ditto . 4 Vertical Angle Books . 5 Abstract of ditto . 4 Computation of co-ordinates, triangles and heights . . . 5

Abstract of Area and Cost of the Revenue Branch Parties according to Jurisdictions.

Provinces.	Scale of Survey.	Area in square miles.	Cost.	Remarks.
			R	
North-West Provinces	16 inches = 1 mile	1,603	3,21,709	
	4 do. = 1 do.	36		
Bengal	16 do. = 1 do.	414	1,23,566	
Punjab	2 do. = 1 do.	2,624(a)	64,530	(a) Topography tested only on maps compiled from the Settlement Survey Maps.
Assam	16 do. = 1 do.	468	95,285	
Lower Burma	16 do. = 1 do.	661	1,78,890	
Bombay	2 do. = 1 do.	3,348	1,05,741	
Central Provinces	16 do. = 1 do.	763	1,34,940	
	. . . . .	5,269(b)	2,78,453	(b) Traverse Skeleton Survey. Maps are plotted on 16-inch scale.
Rajputana	Ditto	243(c)	11,243	(c) Traverse Skeleton Survey with village boundaries.
	Total	15,429	12,14,361	

Note.—The areas of preparatory boundary traversing executed by cadastral survey parties have not been included in this statement.

PART III.

THE OPERATIONS AT THE SEVERAL HEAD-QUARTERS OFFICES.

1. These offices comprise—

(1) The Survey of India Offices at the Presidency.

(2) The Trigonometrical Branch Offices at Dehra Dun.

There has been little or no change in the general arrangement of these offices during the year under report, except that on the transfer of Lieutenant-Colonel W. H. Wilkins, S.C., the permanent charge of the Map Record and Issue Office was assigned to one of the Assistant Surveyors General. The work in all the offices has continued to increase.

Personnel.

Lieutenant-Colonel H. R. Thuillier, R.E., Deputy Surveyor-General, in charge Revenue Surveys, up to 10th March 1886.

Colonel J. Sconce, S.C., Deputy Surveyor-General, in charge Revenue Surveys, from 11th March 1886.

Colonel D. Macdonald, S.C., Officiating Deputy Superintendent, 1st grade, on duty from 9th March 1886, and Officiating Assistant Surveyor-General, from 21st March 1886.

Major C. Strahan, R.E., Deputy Superintendent, 2nd grade, Assistant Surveyor General, up to 16th April 1886.

Lieutenant-Colonel W. H. Wilkins, S.C., Officiating Deputy Superintendent, 2nd grade, up to 2nd November 1885.

Major M. W. Rogers, R.E., Deputy Superintendent, 3rd grade, Assistant Surveyor General, up to 20th March 1886.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, on duty from 10th April 1886, and Officiating Assistant Surveyor General from 17th April 1886.

Lieutenant G. B. Hodgson, S.C., Officiating Deputy Superintendent, 4th grade.

SURVEY OF INDIA OFFICES.

Mr. T. W. Babonau, Registrar.

SURVEYOR GENERAL'S OFFICE.

Mr. M. Francis, Head Clerk.
Babu Banee Madhub Banerjee.
„ Chuni Lall Dey, and one other.

Accounts Section.

Mr. E. D. Algar, Head Accountant, up to 16th July 1886.
Babu Bama Churn Chuckerbutty, Officiating Head Accountant, from 17th July 1886.
„ Raj Krishna Mookerjee.
„ Okhoy Coomar Dutt, (died 29th September 1886) and six others.

General Section.

Mr. J. A. Vallis, Examiner, up to 16th July 1886.
„ T. E. Ware, ditto, from 17th July 1886, on furlough.
Babu Doorga Narain Ghose, Officiating Examiner, from 17th July 1886.
Mr. H. R. D'Mello.
Babu Bheecum Singh.
„ Gopal Chunder Doss, and eight others.

REVENUE SURVEY BRANCH OFFICE.

Mr. A. C. Cunningham, Head Clerk, retired 17th July 1886.
„ E. D. Algar, ditto, from 17th July 1886.
Babu Kalipodo Banerjee.
„ Ram Kristo Chunder.
„ Raj Coomar Dutt.

TOPOGRAPHICAL SURVEY BRANCH OFFICE.

Mr. T. E. Ware, Head Clerk, up to 16th July 1886, furlough from 1st April 1886.
„ J. A. Vallis, Head Clerk, from 17th July 1886.
Babu Doorga Narain Ghose, up to 16th July 1886.

MAP RECORD AND ISSUE OFFICE.

Mr. A. E. Byrn, Head Assistant.
„ H. R. Vallis, Map Curator, and thirteen others.

DRAWING OFFICE.

Mr. G. A. McGill, Chief Draftsman.
„ S. M. Smylie, Head ditto, up to 26th June 1886.
„ P. J. W. Doran, Draftsman, from 1st August 1886.
„ W. Green, Draftsman.
„ J. R. Adels, ditto.
„ A. J. Musgrove, ditto.
„ R. Sinclair ditto.
„ A. S. Bateman, ditto.
„ G. Gill, ditto, and two others.

Native Draftsmen.

Munshi Sonaullah.
„ Nabi Buksh.
Babu Harihur Sen.
„ Mohesh Chunder Shaw.
Munshi Muttiullah.
Babu Purna Chunder Sen.
„ Gopal Chunder Roy, and 36 others.

Surveyors and Assistant Surveyors on duty.

Mr. S. M. Smylie, Surveyor, 1st grade, from 27th June 1886.
„ F. Adams, Surveyor, 2nd grade.
„ A. G. Wyatt, do, 3rd do
„ S. O. Madras, Assistant Surveyor, 1st grade.
„ E. J. Martin, ditto, do.
„ B. M. Wilson, ditto, 2nd grade.
„ J. A. Higgs, ditto, do. from 1st July 1886.

Sub-surveyors on duty.

Babu Modhu Sudun Dutt, and one other.

Additional Establishment.

Mr. W. Stotesbury, Draftsman.
„ P. J. W. Doran, ditto, up to 31st July 1886, and seven others.

ENGRAVING OFFICE.

Mr. C. W. Coard, Superintendent.
„ W. Donaldson, on furlough, from 6th June 1886.
„ G. G. Palmer.
„ D. L. Mitchell.
„ J. Fulford.
„ T. B. Rodger.
„ A. G. Palmer.
„ S. M. Coard.
„ A. W. N. James.
„ A. R. Coard.
„ A. D. M. Chamarett, on leave, from 8th May 1886.
„ E. C. Ollenbach, on leave, from 19th July 1886, 4 Apprentices and 25 Native Engravers, and 1 Storekeeper.

Copper-plate Printing Section.

Mr. W. T. Collins, Copper-plate Printer, and 15 Native Printers, and Pressmen

2. The duties of the Surveyor-General's and the Topographical Branch Offices were carried on by Major M. W. Rogers, R.E., up to the 20th March 1886, and thereafter by Colonel D. Macdonald, S.C.

3. The Revenue Survey Branch Office was supervised by Lieutenant-Colonel H. R. Thuillier, R.E., up to the 10th March 1886, and subsequently by Colonel J. Sconce, S.C., on his return from furlough, who carried on the duties connected with the accounts as well as the correspondence of this Branch.

The Drawing, Engraving and Map Record and Issue Offices were supervised by Major C. Strahan, R.E., up to the 16th April 1886, and thereafter by Lieutenant-Colonel R. Beavan, S.C.

Lieutenant G. B. Hodgson, S.C., has continued to hold the post of Personal Assistant to the Surveyor-General.*

MAP RECORD AND ISSUE OFFICE.

4. From the 1st October 1885 up to the 15th April 1886, Major C. Strahan, R.E., Deputy Superintendent, 2nd grade, and Assistant Surveyor General, held charge of the Map Record and Issue Office. He was relieved by Lieutenant-Colonel R. Beavan, B.S.C., Deputy Superintendent, officiating 3rd grade, who has since superintended it.

5. The number of maps issued during the year under review is shown in the following statement :—

Maps issued.	Number.	Value.
		₹
General maps to Government officials	64,028	51,410
Ditto to India Office, London	4,084	6,028
Ditto to Agents	2,748	4,740
Total .	70,860	62,178
Cadastral maps to Government officials	1,39,428	1,04,571
Grand Total .	2,10,288	1,66,749

6. As compared with the previous year, there is a decrease in the number of maps issued to Government officials, both general maps and cadastral, but owing to the increased number of maps sent to England and to agents for sale, the total number of general maps issued is somewhat larger than was issued in 1884-85. Since April, a new system has been introduced of debiting other departments with the value of all maps issued on public service. This may be expected to have the effect of reducing for a time the numbers of maps indented for by officials, but at the same time it increases materially the clerical work of this office.

7. The number of applications for copies of maps is almost the same as during the previous twelve months. In the Revenue section of this office, 617 applications were received for extracts from the original records of the Revenue surveys, and 2,638 copies of village plans were supplied at a cost of ₹5,494, which was recovered from the applicants.

* Colonel Macdonald reports as follows :—

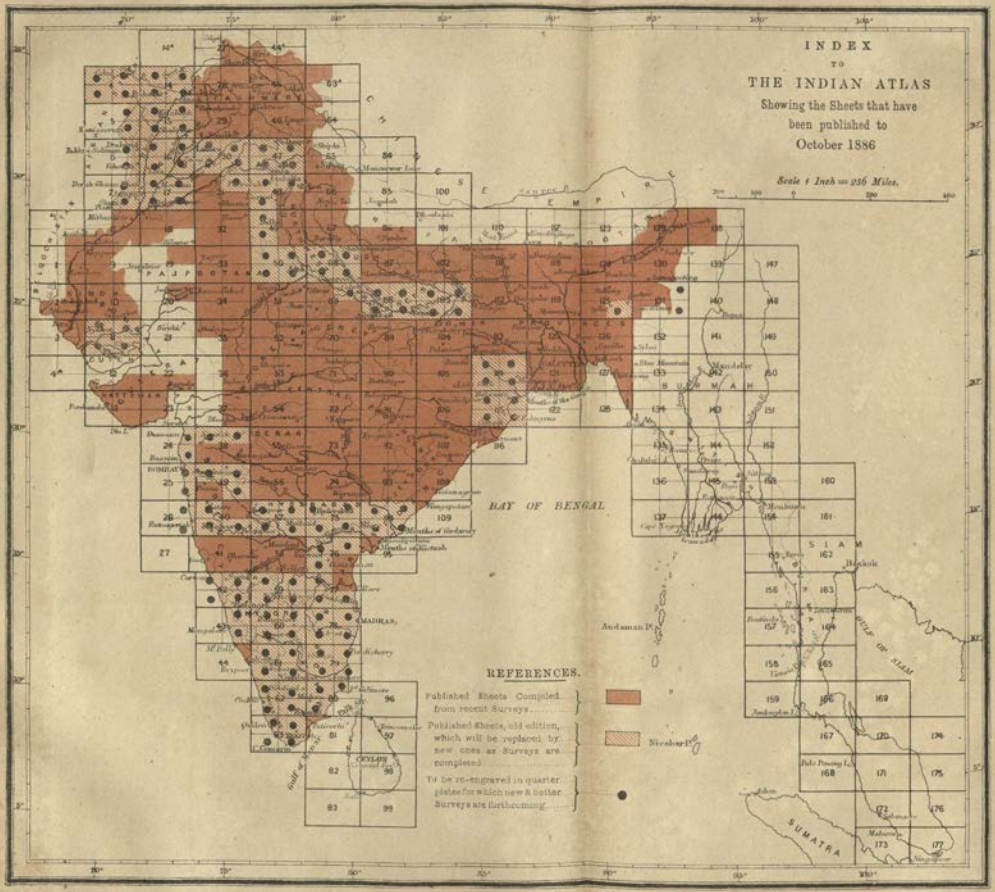
The Registrar of the Survey of India Office, Mr. Babonau, has, as usual, performed his duties in a very satisfactory manner.

Mr. Francis, Head Clerk, Surveyor-General's Office, Mr. E. D. Algar, Head Accountant, and Mr. J. A. Vallis, Head Clerk, Topographical Branch, have all worked hard and steadily.

Babus Banee Madhub Banerjee, Doorga Narain Ghose, Bamachurn Chuckerbutty, Bheecum Singh, Chuni Lall Dey, Rajkrishna Mookerjee, and the remaining clerks have been regular in their attendance, and attentive to their duties.

In the Revenue Branch Office, the Deputy Surveyor General reports most favourably of Mr. E. D. Algar and Babu Kali Podo Banerjee, and names Babus Ram Kristo Chunder and Raj Coomar Dutt as deserving of mention.

Mr. A. C. Cunningham, late Head Clerk of the Revenue Branch Office, retired on a pension on 17th July 1886, after a total service of over 30 years, but he lived to enjoy his pension for only three months.



Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India, Survey of India Offices, Calcutta, January* 1887.

8. The following statement gives the income from map sales :—

	R	a.	p.
Realised from map sales and paid into the Government Treasury	7,741	0	0
Realised from map agents	991	14	0
Total	8,732	14	0

9. The following figures show briefly the details of work :—

Applications received for maps by letters, indents and telegrams	2,387
Letters issued in reply	2,788
Invoices and receipts issued for published maps	1,773
Ditto ditto for cadastral do.	290
Ditto ditto for extracts from original records	210
Packets, parcels and town despatches	2,685
Packages despatched by rail and steamer	254
Published maps, coloured for sale and issue	20,396
Ditto ditto for other departments	2,630

10. The publication of the new Catalogue of Maps published by the Department is being proceeded with. Two parts, those of the Atlas of India and the Punjab, have already been issued, and those of the remaining Provinces are in various stages of progress. Mr. J. P. Doran has been employed chiefly on this work, besides attending to the arrangement and sorting of the maps and the completion of the racks. The latter, as reported last year, are practically complete, that is, in their present state, they are sufficient for all probable requirements for some time to come, but still there are some minor additions which will have to be carried on by degrees as money is available from time to time: a considerable amount of work has been done in this direction during the past year.*

DRAWING OFFICE.

11. Up to the 15th April 1886, the duties connected with the Drawing Office were supervised by Major C. Strahan, R.E. Since that date they have been under the superintendence of Lieutenant-Colonel R. Beavan, B.S.C.

12. This office is divided into three Sections—Section I dealing with new compilations and all maps connected with the Topographical Surveys; Section II with the maps connected with Revenue Surveys, other than Cadastral; and Section III, which deals with Cadastral maps only. A statement in detail is given in the appendix, of the amount of work turned out in the various sections.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

13. Section I has been kept fully occupied during the past year. A great deal of work has been done for the Indian and Colonial Exhibition in London. A map of the world on Mercator's projection was prepared, showing the import and export trade of India with other countries during 1884-85. A series of maps was also prepared with a view to showing at a glance the percentage of various crops grown in different districts of India. These were coloured by hand on the 64-mile outline map of India. The maps to illustrate the Density of Population, Emigration, External trade, Land settlement and revenue, Geology, &c., of India have been completed, as well as the Religion map which was described in last year's report.

14. The model of India in relief, which was alluded to in last year's report as being then under preparation by Major C. Strahan, was completed and sent to the London Exhibition; it was prepared in plaster-of-paris and coloured by hand. Another cast has been taken, and this will be completed for His Excellency the Viceroy, by special request.

* Colonel Beavan reports that Mr. A. E. Byrn has worked hard, and that Messrs. H. R. Vallis and B. M. Wilson have discharged their duties most efficiently. Mr. Doran has worked well and steadily; Sub-surveyors Modhusudun Dutt, Babu Ashutosh Kar, Mr. S. Hazrah and the other clerks employed in the office have all worked hard and rendered good service.

15. Three small skeleton maps have been drawn, showing (*a*) the Burma and Assam Frontier, (*b*) the Punjab and Afghanistan Frontier, (*c*) the Sind and Baluchistan Frontier. These maps are intended for attachment to official reports, for the illustration of political questions dealing with large areas of country, on which any routes for transfrontier railways or expeditions can be readily sketched in by hand.

16. Several large maps of India on the 32-mile scale have been prepared for general use, similar to the well-known "Railway map"; one showing Canals, another Feeders to Railways, Roads, &c., and a skeleton map for lecture rooms and schools. The last has also been published on a smaller scale.

17. The small District maps for Administration Reports have all been completed, excepting those of two districts in Assam and two in the Central Provinces. These maps have entailed a great deal of work in the Drawing Office, and it is to be hoped that they will be appreciated by the District officials for whose use they have been prepared.

18. Several quarter-sheets of the Indian Atlas have been specially prepared by hand for the purpose of experimenting in different methods of reproduction, one having been drawn for reproduction by photo-zincography and others in different styles for heliogravure, with a view to ascertain which is the best method.

19. The regular work of the section has progressed well; 25 Atlas Sheets are in hand, in different stages of progress, under preparation for the Engraving Office. Several odd jobs have also been done for Government and various officials.

20. Twelve District maps on the $\frac{1}{4}$-inch scale have been prepared from Atlas Sheets or corrected to date, and the Provincial maps on the 16-mile scale have been proceeded with. Additions have been made to the new 32-mile map of India which is being engraved. It is intended to have this map transferred to stone, and the small portion that still remains unengraved, will be drawn on the stone by hand, so that a preliminary edition of this beautiful map will be available for issue to the public in a few months.

21. As usual, the fair standard sheets received from field parties have been examined, and passed on to the Photographic Office for reproduction. A great deal of work had to be done on these sheets in many cases before they could be published, but steps have been taken to have them prepared in the field party offices in a strictly uniform manner, so that in future the amount of this kind of work will be very greatly reduced.

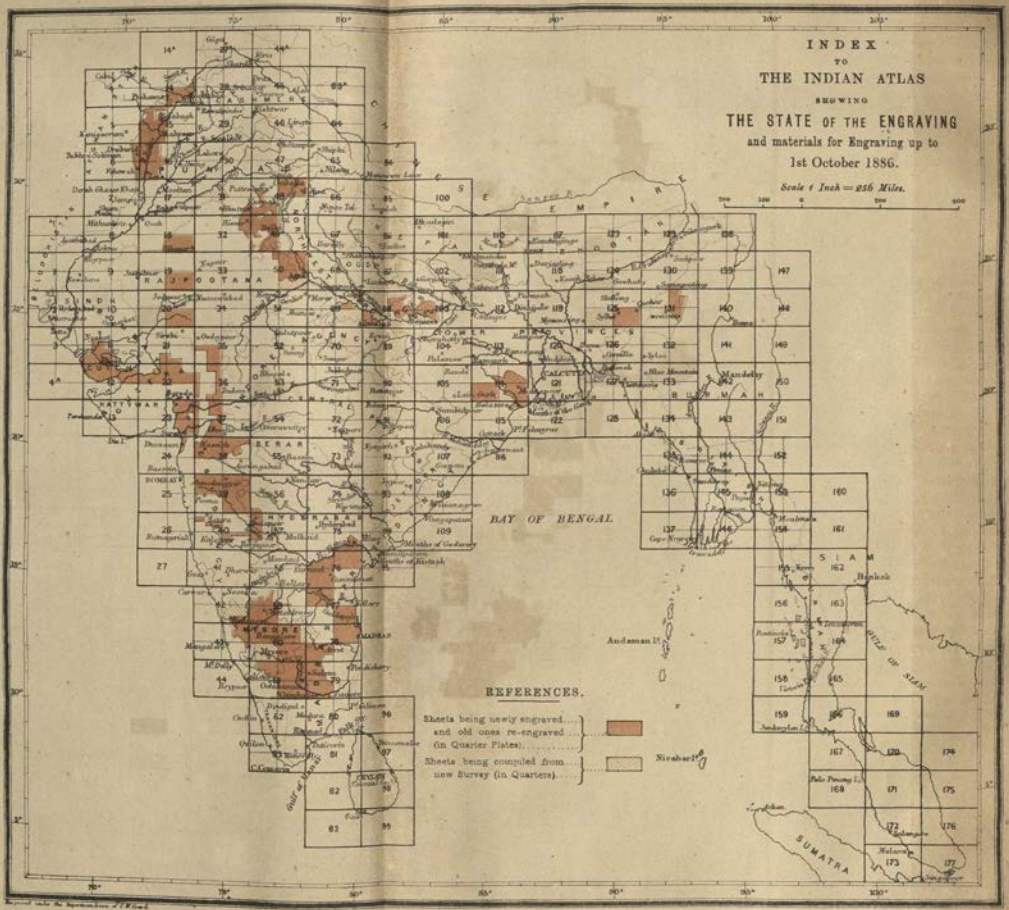
22. The preparation of the Index maps for the Annual Report has been comparatively simple this year, as in most cases those used for last year's Report have sufficed, with the necessary additions, to bring them up to date.

SECTION II.—REVENUE MAPPING.

23. In this section much work has been done for various Government officials in preparing copies of Revenue records as shown in the appendix. A considerable number of maps have also been coloured. All the fair maps sent in by the field parties have been examined, and the headings, foot-notes, &c. have been rectified and made complete for photo-zincography. Part of the special work performed during the year by this section is the preparation of the maps of Districts Prome, Tharawaddy and Henzada on the 2-inch scale for reduction to 1-inch, as well as those of Districts Gorakhpur and Mirzapur. A new map of the city and cantonment of Benares has been taken in hand. It is to be drawn on the scale of 8 inches to the mile by reduction from the cadastral sheets.

SECTION III.—CADASTRAL MAPPING.

24. The work in this section has proceeded steadily. The number of sheets sent to press is somewhat less than during the previous year, but this is entirely due to the fact that the supply from field parties was smaller; on the other hand, a large number of volumes (46), containing original survey sheets, have been arranged and bound up for record, and 150 volumes containing sets of printed sheets have been prepared for the Government of Burma.



Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Officiating Surveyor General of India, Survey of India Offices, Calcutta, January* 1887.

25. The publication of the cadastral maps of Districts Benares and Ballia was completed during the year; also of the districts of Prome, Bassein and Henzada in Lower Burma, and of Pooree District (Khorda Estate) in Bengal: of Dehra Dun, a few sheets only remain unpublished.

26. The map of the city of Benares on the 32-inch scale occupies 5 sheets. The *mohulla* names were given on separate sheets with a view to their being printed in red, but this was found impracticable, as the blocks of buildings had been shaded with fine lines, and the names could not be printed clearly on the face of the map. The only alternative was to give the names in a separate reduced index map on the margin of each sheet.

27. The large scale plans of the towns of Akyab, Prome, and Henzada, (scale 64 inches = 1 mile) have also passed through this office. In addition to the number of copies of cadastral maps that are usually ordered, a few extra copies of these city plans have been printed for stock, as they will probably be wanted by the local officials, or private individuals, in the future.*

THE ENGRAVING OFFICE.

28. During the year, three of the European engravers have been on long leave—two letter engravers and one hill etcher: the native hill etcher, who was taken by Colonel Waterhouse last year for heliogravure work, has been employed by him during the whole of this. The amount of outlining and lettering is slightly below last year's out-turn, consequent upon the absence of the engravers on leave. The hill etching is above last year's out-turn, while the engraving of other details is below it; still the aggregate work in this branch is slightly above last year's amount.

29. The out-turn of work of the Printing Section is much above that shown in last year's report, and is the largest ever accomplished by this branch; it continues to increase very rapidly and great want of space is felt as the work grows.

30. The new map of India in six sheets, on the scale of 1 inch = 32 miles is well advanced; the hill work in sheet 3 is being completed from recent surveys, and railways, &c., to date are being engraved in sheets 4, 5 and 6. Duplicate plates of sheets 1 and 2 have been prepared by the electrotype process, and the remaining sheets will be treated in the same manner in order that one set of plates may contain only material derived from actual survey, while the other set will be completed from any geographical information that may be available, such as route surveys and reconnaissances and will be kept up to date and corrected year by year. The two maps of India on the scale of 1 inch = 64 miles (with and without hills) have been brought up to date.

31. The provincial map of Bengal in two sheets on the scale of 1 inch = 16 miles is making good progress. Sheet 1 is nearly completed, but the hill etching of sheet 2 remains to be done. Rajputana, on the 16-mile scale, is complete so far as surveys have yet extended, but a small portion of country is still unsurveyed. Meanwhile, the map will be printed from stone in the Lithographic Office. A map of the Punjab on the same scale is being engraved, and one of the North-West Provinces and Oudh has been commenced. Additions have been made to the maps of Assam, the Central Provinces, the Central India Agency, and the Patna Division, and several miscellaneous plates have been completed, among which are a map of Berar, a form of Commission for Native Officers, the Viceroy's Arms, six plates ruled for Tints, and numerous Scales of different kinds.

32. Of the sheets of the Atlas of India, which are engraved on a uniform scale of $\frac{1}{4}$ inch = 1 mile, sixteen new quarter-sheets have been projected during

* Section I has been under the immediate charge of Mr. G. A. McGill, Chief Draftsman, who has conducted the duties of his post in a most efficient manner; the Revenue Section has been in charge of Mr. S. M. Smylie, Head Draftsman. Both of these officers are old and well-tried surveyors and have, during the past year, fully kept up their previous reputation. Mr. Stotesbury is also a reliable and hard-working surveyor who has had charge of the cadastral section. Mr. F. Adams has had charge of the Examining Branch of Section I, which is located in a separate room, and almost forms a separate section. Here every topographical, general, or engraved map has to undergo a strict scrutiny before it is published, and the press of work is usually very heavy.

The following Surveyors and Assistant Surveyors have also been employed in the Drawing Office, *viz.*:—Mr. A. G. Wyatt, Mr. S. O. Madras, Mr. E. J. Martin, and Mr. J. A. Higgs. They have all worked steadily and well. The European and native draftsmen have done good work.

the year, thirty-eight have been repaired and added to, and nine have been completed and published. At present there are sixty-one plates in hand in various stages of progress. During the past twelve months 253 plates have been worked upon in this office. The hill etching done covered 1,552 square inches of copper plate, 324,589 letters were cut and 2,727 square inches of topographical detail. In the Printing room 19,305 impressions were pulled. The detailed statement of work done during the year will be found at page lxxix of the appendix.*

THE PHOTOGRAPHIC OFFICE.

33. Lieutenant-Colonel J. Waterhouse remained in charge of the office until the 21st March, when he was obliged from ill-health to take short furlough to Europe, and Lieutenant-Colonel W. F. Badgley officiated for him until the close of the year. Lieutenant J. M. Fleming remained attached as Assistant Superintendent until 9th August, when he was transferred to the Baluchistan Topographical Party. As it was considered desirable to have a second officer in training in the Photographic and Lithographic Offices, Mr. T. A. Pope of the Madras Revenue Survey, who had been very favourably reported on as likely to prove well qualified for the post, was transferred from the Madras Survey, and appointed to the Survey of India as Assistant Superintendent. He joined the office on 14th October 1886.

34. The out-turn of the office, as shown in the annexed abstract, has again been very large, and in the Zinc Printing Section shows a considerable increase. In the Normal Sections, engaged in the ordinary departmental and extra-departmental work, the number of subjects reproduced shows a falling off, though still much above the average, being

Personnel.

Lieutenant-Colonel J. Waterhouse, B.S.C., Assistant Surveyor General in charge, on furlough from the 21st March 1886.

Lieutenant-Colonel W. F. Badgley, B.S.C., Officiating Assistant Surveyor General, in charge, from 21st March to 30th September 1886.

Lieutenant J. M. Fleming, Assistant Superintendent, from 1st October 1885 to 9th August 1886; transferred to the Baluchistan Topographical Party.

NEGATIVE SECTION.

Normal Establishment.

Mr. J. Mackenzie, Photographer.
„ C. DeCruze, Assistant ditto.
Ismail Khan, „ ditto.
2 Negative retouchers, 2 glass-cleaners, and 1 bhistie.

Cadastral Establishment.

Mr. C. Marshall, Photographer.
„ L. Lagnier, ditto.
„ T. Lloyd, Assistant ditto.
3 Assistant Photographers, 3 Negative retouchers, 5 glass-cleaners, and 1 bhistie.

PHOTOGRAPHIC TRANSFER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Asst. ditto.
2 labourers.

Cadastral Establishment.

Mr. R. George, Photographer, in charge Silver Printing Section, from 1st October to 15th December 1885, in addition.
2 Assistant Photographers and 2 labourers.

SILVER PRINTING SECTION.

Normal Establishment.

Mr. G. G. Dempster, Photographer, working in the Negative Section (Normal Establishment).
1 Assistant Photographer and 1 labourer.

HELIOGRAVURE SECTION.

Normal Establishment.

Mr. A. W. Turner, Photo-Engraver.
Babu Joy Kristo Shaw, Engraver, drawing his pay from the Engraving Office.
1 Assistant Photographer, 1 copper-plate printer, and 4 pressmen.

COLLOTYPE SECTION.

Normal Establishment.

1 Printer, 1 glass-cleaner, and 2 pressmen.

ZINC PRINTING SECTION.

Normal Establishment.

Mr. B. Mackenzie, Zincographer.
1 Writer, 4 zinc-correctors, 5 zinc-printers, 4 spongemen, 3 zinc-grainers, and 17 pressmen.

Cadastral Establishment.

Mr. J. Watson, Zincographer.
„ E. A. LeFranc, ditto.
„ J. B. Mackenzie, Assistant Zincographer.
9 zinc-correctors, 1 writer, 9 zinc printers.
6 spongemen, 11 zinc-grainers, and 30 pressmen.

GENERAL OFFICE ESTABLISHMENT.

Normal Establishment.

Mr. W. Moore, Store-keeper.
Babu Kanny Lall Sen, Clerk and Accountant.
Babu Gopal Chunder Mookerji, Clerk.
1 Clerk.

Cadastral Establishment.

Mr. H. Haward, Head Assistant, in charge Collotype Section and also in charge Silver Printing Section, from 16th December 1885 to 30th September 1886.
1 Clerk and 1 extra Clerk.

APPRENTICES.

Normal Establishment.

Mr. C. Meade, working in the Silver Printing Section.
„ J. T. Meade, working in the Collotype Section.
„ U. S. Ravenscroft, working in the Zinc Printing Section (Cadastral), from 1st October 1885 to 31st August 1886. Transferred to the Lithographic Office, 1st September 1886.
P. C. Michael, working in the Negative Section.

* Mr. C. W. Coard, Superintendent, has conducted the duties of this office in a very satisfactory manner. His tenure of the appointment has been further extended for another twelve months. During Mr. Coard's absence on privilege leave Mr. G. G Palmer officiated for him. The work turned out by this office is of the usual high quality, and the amount done proves that the engravers and printers have worked well and steadily. The Europeans and, with few exceptions, the natives, have done very well.

1,518 (892 departmental and 626 extra-departmental), while last year it was 1,702 (853 departmental and 849 extra-departmental). The number of negatives taken has risen, from 2,573 to 2,671, including 70 reversed negatives and transparencies. The number of zinc-plates printed is less by 103 than it was last year, but the number of press pulls, which is the real criterion of the work done, exceeded that of last year by 29,892, while the number of complete copies was larger by 108,619; this is due to the comparatively large amount of small subjects, several going on one plate.

35. The amount of silver printing is again comparatively large and shows an increase of 1,493 over last year, due to a large order for copies of the sketches done by Major E. L. Durand, attached to the Afghan Boundary Commission, as well as for photographs taken in connection with the Indo-Colonial Exhibition. The out-turn of the heliogravure and collotype prints has not been quite so large as last year, but the processes are progressing satisfactorily. A very large increase of electrotyping work has been done during the year in duplicating the engraved copper-plates of the Atlas of India and Standard Maps.

36. In the Cadastral Sections the out-turn has been well up to the average, the number of sheets printed off being 122 more than last year, though the number of pulls is 16,008 less, owing to smaller numbers being printed.

General Abstract of Out-turn and Value of work done between 1st October 1885 and 30th September 1886.

Description of Work.	Number of Sheets, Sections, or Subjects.	Negatives.		Photo-zincographic Printing.					Silver and other Printing.			Heliogravure and Electro-typing.					Photo-collotype.		Value.
		Number of Negatives, (Direct).	Number of Negatives (reversed) and transparencies.	Number of Photo. transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies	Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates, Photo-electrotyped.	Heliogravure Plates, Photo-etched.	Heliogravure Prints.	Photo-Blocks.	Electrotypes.	Photo-collotype Plates.	Photo-collotype Prints.	R a. p.
Departmental Maps and Plans	892	1,901	11	1,848	602	612	96,361	150,219	170	152	39	3	7	...	2	13	21	845	52,502 12 11
Cadastral Maps	5,203	3,387	...	3,492	5,245	5,282	154,898	144,760	...	...	...	...	...	...	...	...	...	...	73,615 14 0
Extra-Departmental Maps and Plans	626	700	59	472	208	211	55,440	117,770	5,229	20	48	9	11	...	1	...	22	4,035	27,749 7 0
Total	6,721	5,988	70	5,812	6,055	6,105	306,699	412,749	5,399	172	87	12	18	...	3	13	43	4,880	1,53,869 1 11

37. The total cost of the office amounted to R1,66,122-9-9, as far as can be estimated, while the value of work done and other credits amounted to R1,58,149-14-6, thus showing a balance against the Department of R7,972-11-3. This, however, is explained by the fact that owing to supplies of paper for 1885-86, arriving later than usual, their cost, amounting to R40,531-13-0, is included in this year's accounts instead of last year's, unduly increasing the balance in favour of the office last year and against it this year.

38. Under the orders of Government a strict system of book-debit for work done for other departments was introduced from the 1st April. A system of noting the value of all work done for other departments had already been in existence for some time past and fixed rates had been established for all classes of the work ordinarily done in the office. The rates were carefully revised and the charges for zinc and litho. printing modified, so as to enable one set of rates to be used by the Photographic and Lithographic Offices here and by the Photo-zincographic Office at Dehra Dun. The new system entailed a good deal more work, and the appointment of an additional clerk was sanctioned for this purpose. As far as can be judged at present, after a few months' experience, the new system has worked well and the rates seem to be about correct, but they will be revised, if necessary, before the commencement of the new financial year.

39. There is nothing specially worthy of note in connection with the ordinary work of the office during the year. The departmental publications have been larger than usual and include, among the General maps, a Map of India showing Feeders to Railways, on the scale of 1 inch = 32 miles, and a reprint

of the Railway Map on the same scale. Among the Provincial maps, a Map of the Central Provinces on the scale of 1 inch=32 miles. A very large number of the District maps on the scale of 1 inch=8 miles was printed off. These maps have been specially prepared for the illustration of Administration Reports, and should be very useful for that purpose. The detailed list of the districts published will be found in the appendix.

40. Three hundred and fifty-nine sheets of standard maps have been printed, including 6 sheets of the Andaman Survey; 38 sheets of the Burma Survey in Districts Pegu and Hanthawaddy, Tharrawaddy and Bassein; 40 sheets of the Gujarát Survey; 23 of District Hissar; 52 sheets of the Hooghly River Survey; 21 of the Kathiawar Survey; 42 of the Konkan Survey; 16 of District Montgomery and 14 of the Mysore Survey. Among City and Cantonment plans may be mentioned—the City of Mysore on the scale of 12 inches = 1 mile, Ajmere City and Environs; City and Cantonment of Bhuj. Of the extra-departmental work may be noted maps of Burma and regions adjacent for the Quartermaster General's Department and maps, for the Camp of Exercise, of the country between Umballa and Delhi. Several military maps of country 10 miles round various cantonments, have been reproduced in this office, as well as in the Lithographic Office, under the direction of the Intelligence Branch of the Quartermaster General's Department. These maps are from special surveys made by officers of the garrisons, and in many cases are fit for reproduction by photo-zincography; in other cases they are lithographed. Three river charts have been reproduced for the Port Officer. The campaign in Burma has not given so much work as might have been expected, but a good deal has been done in the way of reproducing sketches and maps for the use of the force. For the Meteorological Department a series of Wind Charts of the Bay of Bengal were reproduced. For the Telegraph Department an extensive series of diagrams of telegraph stores was reproduced, besides a Telegraph Map of India.

41. The Photo-collotype process has been making good progress during the year and has been utilised in various ways for extra-departmental work. Some plates of very small coins have been reproduced for the Asiatic Society, also some plates of microscopic sections of tree fungi, from the original negatives by Dr. A. Barclay. Prints were also made of some enlargements of maps of the Ordnance Survey for the use of draughtsmen and engravers. Experiments have been made with fair promise of success in transfer from photo-collotype plates to stone.

42. The heliogravure processes have also made fair progress, though the out-turn has not been so large as last year. Some very successful transfers to stone were made from specially prepared photo-electrotype plates, and though more expensive and slower, this method appears likely to offer the most satisfactory solution of the problem how to break up the delicate photographic image sufficiently to print clearly from stone or zinc without destroying fine details.

43. The electrotyping arrangements have been greatly extended during the year with the object of duplicating incomplete Atlas sheets and standard maps, so that they may be temporarily completed for issue pending the engraving of the final results. This is a very valuable addition to the capabilities of the office and will prove of great utility, especially as no difficulty has been found in duplicating sheets up to the size of double-elephant.

44. During the early part of the year under review the final plans and estimates for the new Photographic and Lithographic Offices were completed by the Government Architect, and after approval by the Surveyor General were returned to the Public Works Department, Government of Bengal. Urgent representations were again made to the Government of India regarding the early provision of suitable accommodation for these offices in one block of buildings—a question which has now been under consideration for the last 16 years. The Hon'ble Sir S. C. Bayley, K.C.S.I., visited the Offices in January 1886, to see the state of things. Owing, however, to financial difficulties it was found impossible to make any provision for this purpose in the Budget for the current year and nothing has since been done.

45. Lieutenant-Colonel Waterhouse has forcibly represented the evils and inconvenience of the present arrangements in a memo. prepared for Sir S. C. Bayley (printed in the appendix, p. lxxxv).

46. They may be summarised as follows:—

I.—The loss of money in house rent: the total amount paid yearly in rent for the three houses—No. 1, Camac Street (lower floor), occupied by the Lithographic Office, and Nos. 1 and 2 Wood Street, occupied by the Photographic Office, is ₹10,980, besides taxes, amounting to ₹943, or in all a sum of ₹11,923. Taking the cost of the new offices, as estimated, at about ₹2,16,000, the interest on this sum at 4 per cent., would amount to ₹8,640. It is clear, therefore, that the erection of the new building would effect a large saving in rent alone, while further savings would also accrue by the greater economy with which the offices could be worked when concentrated together, besides the increased efficiency, convenience, and other advantages in working that would be gained.

II.—The division of the Lithographic and Photographic Offices into three separate houses, the former at some distance from the latter, necessitates references and visits to and fro, and renders efficient supervision difficult. The zincographic and lithographic presses, all doing similar work, are distributed between the three houses and scattered in small rooms. Were they brought together in one large room, as proposed in the new buildings, there would be less loss of power, and better work could be done by the use of stone or zinc, as might be best suited to the particular class of work. The printing staff, being concentrated, could work together with greater advantage and economy, and the whole could be more effectively and easily superintended.

III.—The present accommodation in private houses is quite unsuitable for technical offices—requiring special arrangements for water-supply, for washing negative plates and prints, and heating apparatus for drying sensitised papers and plates, also for working heavy presses and machinery. The want of proper permanent arrangements lowers efficiency.

IV.—The Photographic glass-house, originally built in 1869, in a light way, quite as a temporary measure, is very dilapidated and otherwise unsuitable for the work with large plates as now carried on. The touching up and finishing of negatives has to be done in an open tiled shed, exposed to all weathers. There is no proper place for storing negatives that are required for further use.

V.—The accommodation of the Silver-printing Section in an old cook-house, very damp and close to a drain is quite unsuitable for such work.

VI.—For want of proper store rooms the photographic chemicals, apparatus, and stores are scattered between Nos. 1 and 2 Wood Street, causing great inconvenience and making it exceedingly difficult to keep things in order and guard against loss and waste by spoiling.

VII.—In the Lithographic Office, besides the inconveniences of separation from the Photographic Office already noticed, the arrangements for the type printing are very cramped and unsuitable: there are no proper rooms for keeping stores or the fast-accumulating records and file proofs, and the printing machines cannot be worked by steam power.

47. The fact that the provision of new buildings for these offices has been under consideration for so many years with the constant prospect of something being done at an early date, has, in many ways, prevented better working arrangements being made, as it has always seemed undesirable to incur expenditure for temporary buildings or fixtures in these hired houses. Work has been regularly carried on and has largely increased in both offices in the face of many grave disadvantages and inconveniences, but the need for some better arrangements is none the less urgent, and it is to be hoped that the settlement of this important question may not be any longer delayed.

Further details of the working of the office and the different processes employed are given in the appendix.

48. While on furlough Lieutenant-Colonel Waterhouse visited, with the sanction of the Secretary of State, various establishments in England and on the Continent, with the object of acquiring information on the latest improvements. His report, which was submitted to the Secretary of State, has not yet been received.*

THE LITHOGRAPHIC OFFICE.

49. This office was in charge of Lieutenant-Colonel J. Waterhouse till the 20th March, when he proceeded on furlough, making over charge to Lieutenant-Colonel W. F. Badgley, who held it for the remainder of the survey year.

Personnel.

Lieutenant-Colonel J. Waterhouse, S.C., Assistant Surveyor General, in charge, from 1st October 1885 to 20th March 1886.
Lieutenant-Colonel W. F. Badgley, S.C., Officiating Assistant Surveyor General, in charge, from 21st March to 30th September 1886.
Lieutenant J. Fleming, S.C., Assistant Superintendent, from 1st October 1885 to 9th August 1886.
Mr. H. L. Lepage, Head Assistant.
Babu Ambica Churn Mookerji, Examiner.
Munshi Sobhan Buksh, and 24 others. } Draftsmen.
Mr. D. Deas, Head Lithographic Printer.
„ B. Wilson, Assistant Lithographic Printer, and 74 others.
„ E. DePyvah, Head Type Printer, and 25 others.
6 clerks and 12 others.
Mr. G. A. Lefranc, } Apprentices.
„ E. Dowling, }

50. The out-turn of lithographic work performed during the year, as shown in the annexed abstract, was again very large. The number of subjects printed off amounted to 677, of which 190 (including 75 forms) were departmental and 487 extra-departmental. Reckoned by the total number of pulls, 424,872, the number of impressions printed off was 92,654 more than last year, though the number of complete copies, 356,877, was 11,099 less than last year. This large increase is due to the larger number of departmental forms printed. The type work has again increased, the number of items set up being 5,566, and the number of copies printed off being 488,796, as against 5,687 items and 464,976 copies last year.

General Abstract of Out-turn and Value of work done between 1st October 1885 and 30th September 1886.

Description of Work.	Lithographic Printing.				Type Printing.		Total number of pulls.	Number of copies.	Value.	Remarks.
	Number of sheets or subjects.	Number of Stones.	Number of coloured copies.	Number of uncoloured copies.	Number of pages or items.	Number of copies.				
Departmental Work.									R a. p.	
General maps	32	42	612	1,262	...	...	9,221	1,874	2,710 8 0	
	7	14	...	...	...	...	...	...	382 15 0	Not yet printed.
Provincial maps	10	14	...	1,375	...	...	1,375	1,375	369 6 0	
District maps	4	4	...	450	...	...	450	450	270 13 4	
	5	5	...	...	...	...	...	...	541 12 0	Ditto.
Plans of Cantonments and Cities	3	5	100	200	...	...	300	200	60 5 0	
Atlas sheets	2	2	...	200	...	...	200	200	160 4 2	
	1	1	...	...	...	...	...	...	249 9 0	Ditto.
Standard sheets	14	14	...	3,210	...	...	3,210	3,210	3,581 0 10	
	5	5	...	...	...	...	...	...	1,588 12 0	Ditto.
Index maps	5	12	2,500	500	...	...	5,550	3,000	315 14 8	
Miscellaneous	37	45	200	13,698	...	...	14,583	12,798	661 5 4	
Departmental forms	75	75	...	178,905	...	...	230,814	178,905	10,846 13 2	
Total	190	237	3,312	198,600	...	...	266,503	201,912	21,859 6 6	
Work done for other departments	487	420	20,845	134,120	...	...	158,369	154,965	27,226 7 5	
Total of Drawing and Printing in Lithographic Office, Survey of India Department	677	657	24,157	332,720	...	...	424,872	356,877	49,085 13 11	
Work done in Type Section	...	...	...	...	5,566	488,796	928,114	...	13,513 0 0	
Total Rupees	...	...	...	...	...	...	...	...	62,658 13 11	

51. The Military and Railway map of India, on the scale of 32 miles = 1 inch, in four colours, of which the commencement was noticed in last year's Report, has made good progress during the year. Four sheets have been completed and proofs forwarded for approval; 4 other sheets are in progress, and the whole map will probably take about eighteen months more to complete. It will be a very good specimen of chromo-lithography.

* Lieutenant-Colonel Waterhouse continues to report very favourably of his European assistants, Messrs. H. Haward, A. W. Turner, J. Mackenzie, B. Mackenzie, J. Watson, H. Harrold, C. Marshall, R. George, L. Lagnier, E. A. Lefranc, G. G. Dempster, T. Lloyd, and W. Moore, as well as the Head Clerk, Babu Kanny Lall Sen, who have all performed their duties very satisfactorily; also of the native clerks, draughtsmen and photographic assistants.

52. A great deal of work was done in the preparation and printing of a series of maps for the Statistical Atlas of India, prepared by Sir E. C. Buck for the Colonial and Indian Exhibition in London. Further progress was also made with the series of chromo-lithographed maps illustrating the material and physical state of India. A map showing the Density of Population, on the scale of 80 miles to the inch, was prepared but not printed. Also an External Trade Route Map, on the same scale, was prepared and printed. The Contour Map, on the 32-mile scale, and Religion Map, on the 80-mile scale, were printed off, and a Canal Map was prepared on the 32-mile scale.

53. Of the regular departmental work, the map of the Nizam's Dominions, in two sheets, on the scale of 1 inch=16 miles, of which the completion was noticed in last year's Report, has been printed off. Three of the new standard sheets of Oudh, on the scale of 1 inch=1 mile, have been drawn and 6 printed: 2 sheets of District Mymensingh were drawn, but none printed.

54. With the exceptions noted above, the extra-departmental work has been of the usual varied character, but shows a slight falling off in quantity, the outturn for the year being 158,369 pulls, or 154,965 complete copies of 487 subjects, as against 171,696 pulls or 201,770 complete copies of 522 subjects last year. The value of the work done has, however, increased, being R27,226-7-5, as against R24,266-12-0 of the previous year.

55. The expenditure of the office for the year was R65,824-6-2, including cost of all materials and plant supplied, and the value of the work performed R63,236-7-2, showing a balance against the Department of R2,587-15. This is partly due to increase in the cost of superintendence, as one-third of Lieutenant Fleming's pay has been debited against this office.

56. Under the orders of Government a strict system of book-debit account of work done for other departments was introduced from the 1st of April last, and the rates of cost of drawing and printing were carefully revised in order to simplify the system of accounts by assimilating the rates of the three printing offices in Calcutta and Dehra Dun. As the old rates were in force from October to March, and the new ones for the rest of the year, the above figures can only be considered approximate as regards the results for the year. No difficulty has been found in working the system and it will no doubt tend to economy. The experience gained in the working of the new rates has shown that a few modifications are desirable and revised rates will be prepared before the commencement of the next financial year.

57. The tabular statements and report showing the details and cost of the work done will be found at page cvii of the appendix.*

MATHEMATICAL INSTRUMENT OFFICE.

58. During the financial year 1885-86, the usual activity has prevailed in all branches of this office. The work has been incessant and shows a tendency to increase year by year. This is evidenced by the figures, which show an increase over the past year under the heads "Receipts," "Issues" and "Repairs."

Personnel.

Major M. W. Rogers, R.E., Assistant Surveyor General in charge, to 20th March 1886.
Colonel D. Macdonald, B.S.C., Officiating Assistant Surveyor General in charge, from 20th to 31st March 1886.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument-maker.
„ F. Marshall, Assistant do. do.
64 Artificers on permanent establishment.
125 Artificers on an average on the temporary establishment.
3 Eurasian Apprentices.

Store Branch.

Mr. C. O. Gray, Instrument Store-keeper.
Babu Woomesh Chunder Chowdry, Material Store-keeper.
1 Packing Sircar.
2 Packers.

Office Establishment.

Mr. M. O'Brien, Head Clerk.
„ W. Campagnac, 2nd clerk, and 6 other permanent clerks.

59. The total increase to the serviceable stock consists of 52,128 instruments of sorts, valued at R1,70,179, the principal details of which are as follow:—

9,038 instruments, valued at R33,615, were received on indent from England; 16,151 instruments, valued at R13,467, were purchased in the local market; 13,453 instruments were manufactured in the workshop at a cost of R21,454; 949 instruments were returned to store in a serviceable condition by various departments.

* Colonel Waterhouse reports that Messrs. Lepage and Deas have performed their duties very satisfactorily. Mr. DePyvah has worked very well and the apprentices have made good progress. The native assistants and clerks have all worked well. Babu Ambica Churn Mookerji, Munshis Abdul Hamid, Abdul Mujid, Mahomed Yasin, Draftsmen, and Babus Russick Lal Shaw, Kedar Nath Ghose, Rajani Kanto Chatterjee, clerks, deserve special mention.

value R17,492; 9,197 instruments were received from various manufacturing offices for stock, value R5,867; 3,103 instruments were received from the repairable stock, after having been repaired at a cost of R21,378 and brought on the books at a valuation of R76,039; finally, 237 instruments, valued at R2,246, were received from other sources.

60. The total issues from serviceable stock amounted during the year to 41,643 instruments, costing R1,77,864.

61. The repairable stock received an addition of 6,320 instruments, valued at R69,860; 3,103 instruments, valued at R54,660, were repaired in the workshop and transferred to the serviceable stock. The total issues from repairable stock amounted to 3,745 instruments, costing R61,328. The value of repairable stock in hand therefore has been increased by R8 532.

62. Table A at page cxii of the appendix shows the values of the issues to, and receipts from, the various departments of the State during the year under review. The receipts show an increase over the previous year of R45,967 and the issues an increase of R6,978, representing a corresponding increase of work in the Store branch.

63. The value of instruments purchased in the local market amounts to R13,467 as against R8,695 in the previous year. The details will be found in Table B, page cxiii of the appendix.

64. Tables C and D at pages cxv and cvii of the appendix give details of the principal instruments manufactured and repaired in the Workshop, and the Profit and Loss Account of the Workshop will be found at page cviii. The profit amounts to R3,887.

65. The value of repairs under all heads shows a nett increase of R2,600 over last year, but the value of manufactures has diminished by R3,700. The total value of work turned out has diminished by about R1,100, as compared with the previous season's out-turn.

66. It is to be noted that last year a reduction was made in the value of repairable stock by nearly R20,000. This year, however, the reverse is the case: the value of repairable stock in hand has been increased by R8,531. This is accounted for by the immense increase in the value of repairable instruments returned to store. The figures for the year under review are R69,650 against R29,509 in 1884-85, being an excess of over R40,000.

67. The building occupied by the Mathematical Instrument Office is old and dilapidated and in a very shaky condition, and the accommodation is altogether inadequate to the growing wants of the office. It is to be hoped that the Government will not defer any longer the commencement of the new building which is so urgently required for this office.*

THE TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

68. The sections under which the work of this office will be reported on are as follows:—

(1) Superintendence, Correspondence, Accounts, Stores, &c.
(2) Computing.
(3) Type-printing.
(4) Drawing and Compiling.
(5) Photo-zincography.
(6) Solar-photography.
(7) Miscellaneous, Meteorology, &c.

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* Major Rogers reports very favourably of the skill, industry, and general good management of Mr. T. Bolton, Mathematical Instrument-maker, and of his Assistant, Mr. F. Marshall. Mr. Gray, the Instrument Store-keeper, is reported to be very pains-taking and efficient. The clerical establishment generally are favourably commented on.

69. (1) SUPERINTENDENCE, CORRESPONDENCE, ACCOUNTS, STORES, &C.—

Personnel.

Colonel C. T. Haig, R.E., Offg. Deputy Surveyor General, in charge of (1), (4), (5), (6) and partly of (7).
Mr. W. H. Cole, M.A., Deputy Superintendent, 3rd grade, in charge of (2) (3) and partly of (7).
Mr. J. Eccles, M.A., Offg. Assistant Superintendent, 1st grade.

(1) Correspondence, Accounts, Stores, &c.

Mr. J. Bond, Surveyor, 4th grade (1st October 1885 to 31st July 1886).
„ F. A. D'Rozario, Head Clerk.
Babu Mirzaji Lal.
And 4 other native writers.

(2) Computing Section.

Mr. C. Wood, Surveyor, 1st grade.
„ H. W. Peychers, Surveyor, 3rd grade.
Babu Gunga Pershad, Computer.
„ Kally Mohun Ghose, „
„ Kally Kumar Chatterji, „
And 14 other Computers.

(3) Type-printing Section.

Mr. B. V. Hughes, Printer.
12 Compositors and apprentices.

(4) Drawing and Compiling Section.

Mr. A. J. Wilson, Surveyor, 1st grade (posted to this Section, 1st October 1885).
„ G. W. E. Atkinson, Surveyor, 1st grade.

Drawing and Compiling Section— continued.

Mr. J. A. May, Surveyor, 1st grade (posted to this Section, 1st November 1885; died 26th June 1886).
„ C. H. McA'Fee, Surveyor, 3rd grade.
„ W. J. Cornelius, Assistant Surveyor, 1st grade.
„ F. E. Warde, Assistant Surveyor, 3rd grade (1st October 1885 to 31st August 1886).
„ H. Sindon, and 7 other Draftsmen, 22 Assistant Draftsmen, Apprentice Draftsmen and Colorists.

(5) Photo-zincography Section.

Mr. C. G. Ollenbach, Zincographer.
„ C. F. Guthrie, Photographer.
2 Assistant Photographers, 2 Native Draftsmen, 1 Assistant Draftsman and 1 Map-keeper.

(6) Solar-photography Section.

Mr. L. H. Clarke, Surveyor, 2nd grade, and Solar Photographer, to 1st January; (retired 30th June 1886).
Sergeant B. Rowland, R.E., Solar Photographer (transferred to this Section, 1st January 1886).

The principal work of this office is the final reduction and publication of the triangulation in all parts of India, including the principal and secondary operations of the Great Trigonometrical Survey. Most of the publications being necessarily of a technical nature and the office being located at a considerable distance from Calcutta, it has been found a great advantage that it possesses small printing, drawing and photo-zincographic establishments, without which the accuracy of the technical details could not have been well maintained, while inaccuracy would have rendered the publications worse than useless. The office has also a depôt of instruments (chiefly of the higher class) and stores attached to it, appertaining to the Great Trigonometrical Survey, of which it was the head-quarters. Among the instruments are, besides several large theodolites, the Colby compensation bars and microscopes for the measurement of base-lines.

70. Owing to the completion of the principal triangulation, there was the danger of these beautiful instruments and apparatus deteriorating from disuse, and of the way to use them being forgotten; steps therefore have been taken to avert this double danger. One of the rooms in the smaller photo-heliographic observatory, though originally built for a transit room, had never been used as such, but only as a store-room for the printed Professional and Synoptical volumes in stock. This was equipped with instruments mounted on isolated pillars, built at a small cost, *viz.*—

A 3-foot meridian circle, for which the double vertical circle of one of the two astronomical alt-azimuths (No. 2) was mounted between two masonry piers, to which 8 micrometers, 4 to each face, were firmly attached, besides another for an index. One of the two Russian pattern* transit instruments: two collimators, one north and one south; and an astronomical clock by Frodsham, with mercury compensation pendulum.

71. A meridian mark, consisting of a masonry structure, presenting an isosceles face, 10 feet high and 8 feet broad at base, was also erected on Vincent's Hill at Mussoorie for the setting of these instruments to the meridian. A little to the east of the larger photo-heliographic observatory a new shed observatory, with corrugated iron roof, capable of being opened up in parts as required, was

* The characteristic feature of this pattern is that the telescope, instead of being straight from object glass to eye-piece, has a diagonal reflector in the centre of the horizontal axis, deflecting the rays to the eye-piece, which is fixed in one of the pivots, the advantage being that the eye is always placed at the same point irrespective of the altitude of the stars. The ordinary eye-end of the telescope is accordingly replaced by a counterpoise to balance the object-end, and this arrangement admits of very low and therefore stable piers for the bearings. There are, however, disadvantages which need not here be enumerated.

erected at small cost accommodating six large instruments, five collimators and a clock, all on isolated pillars, viz.—

A Browning's reflecting telescope, with 9-inch reflector.

A telegraphic-longitude transit instrument, with its two collimating telescopes—north and south.

A (Strange's) zenith sector, with its collimating telescope.

A 3-foot theodolite.

A 2-foot do.

A 3-foot astronomical alt-azimuth (No. 1) with two collimators—north and south—the former being Everest's "phantom" (*vide* p. li of that officer's Account of the Meridional Arc of India), and the latter being an old 24-inch transit instrument by Dollond.

The clock is an old one by Jones, with a gridiron compensation pendulum, and formed part of the equipment of one of the astronomical alt-azimuths.

72. A meridian mark similar to that built at Mussoorie on the meridian of the transit room was built on another part of the same hill on the meridian of the longitude transit instrument. The meridional positions of both these meridian marks were determined by careful series of observations of the Pole Star; one by Major G. Strahan, with a longitude transit instrument, and the other by Colonel Haig, with the Russian pattern transit. The method of determination is described in detail by Major Strahan and will be found in the extract from his narrative report on the Longitude operations in the appendix. In the transit room the instruments (excepting of course the clock) are all on the same meridian. The transit circle can be readily lifted by a system of pulleys (with wire rope), slings, and guides devised for the purpose. It is necessary to raise it about a foot when the mutual collimator readings are taken, and then lower it into its Ys as before, but in order to change pivots east for west, it has to be raised nearly 3 feet, swung round and lowered. The Russian pattern transit horizontal axis is pierced with a circular opening on either side to admit of mutual visibility between the collimators, but the reflector inside the axis intercepts so much of the aperture that it affords more comfort in the mutual reading of the collimators to lift the transit out of its bearings and place it for the while in its box.

73. A working catalogue of 678 stars, derived from the Greenwich 9-year Catalogue, was prepared for Dehra Dún, giving each star's magnitude, right ascension, and setting reading of the circle to the next lower 5-minute division, both for altitude and zenith distance. The catalogue covers a complete belt of the heavens from the equator to north declination 60°, so that no star has a greater zenith distance (north or south) than 30°, and the average interval in time between two successive stars passing is about 2 minutes.

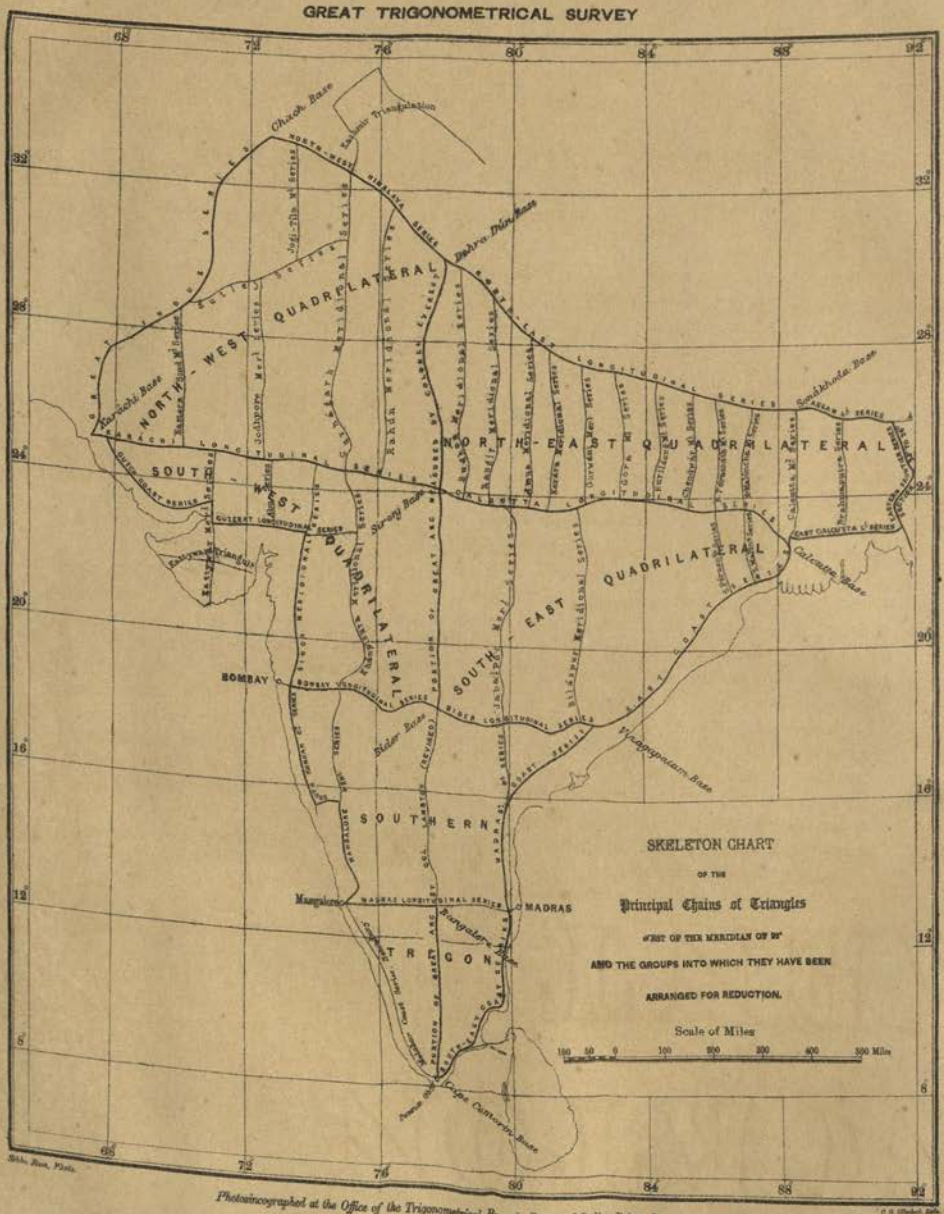
74. A series of observations to determine the latitude of Dehra was taken by Messrs. Wood and McA'Fee to 11 pairs of stars during the months of March and April. The observations indeed included more than that number, but cloudy weather prevented the observations in part or whole to the second stars of several pairs, to the first stars of which complete observations had been taken.

The resulting latitude was:—

By North Stars	30°	18′	54″·5
By South Stars	30	18	54·3
Mean	30·	18	54·4 with a theoretical *probable error* of ± 0″·29

75. The latitude determined by the triangulation in conjunction with the astronomical latitude of Kaliánpur is 30° 19′ 29″·1, the excess (=34″·7) of geodetic over astronomical being due to local attraction. Two other surveyors observed 14 pairs of stars for latitude with the same instrument, but the observations were not reduced. The astronomical clock in the transit room is now constituted the standard time-keeper of the office, and is rated by astronomical observations every day or as often as the weather permits.

76. The new shed observatory has windows on the north side admitting of the observation of three principal stations, Banog H. S., Sirkanda H. S. and Mussooree Observatory, by the two large theodolites, so as to familiarize officers of the department with the use of this class of instruments. All the large class



Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, March 1887

of theodolites in the Dehra store (altogether four), besides the two astronomical alt-azimuths and a Repsold 14-inch alt-azimuth, have been thoroughly cleaned and put into working order.

77. In order to preserve the knowledge of measuring base-lines in the department, a short base-line (231 yards) was measured in the Survey office estate with the Colby apparatus. The direction of the measurement was entrusted to Mr. Cole, and the details are given in his report, at page cxxi of the appendix, from which it will be seen how various are the labours required in this delicate operation, and how necessary it was (in view of the prospect of having to measure probably a base-line in Burma and in the Malay Peninsula), that it should be undertaken. A staff quite sufficient to undertake the measurement of an actual base-line have now been familiarized with the various duties involved.

78. The correspondence and accounts of the Trigonometrical Branch call for no special mention, beyond stating that the work in connection with the protection of the stations has continued to be carried on as before. During the year under report 975 stations have been repaired by district officers at a cost of R3,912. Of the 328 districts from which reports are due, those for 34 were not received; but reminders were sent out, and the reports for 5 districts have since come to hand.

79. (2) COMPUTING SECTION.—During the past year the final reduction and publication of the various operations of the Great Trigonometrical Survey have steadily proceeded under the superintendence of Mr. Cole who has been ably assisted by Mr. Eccles. Among the items specially worthy of note may be mentioned the South-West Quadrilateral, of which the simultaneous reduction of the circuit triangles has been finished. Not much remains to complete the final reduction of the *principal* triangles of this Quadrilateral, and with it that of the whole of India west of meridian 92°. The final reduction of the Latitude observations from Colonel Lambton's time up to season 1884-85 is now complete; the preparation of the results for the press is well advanced, and the printing of them has been commenced for publication in one of the series of Professional volumes, which will now progress steadily towards completion. A very considerable portion of the *secondary* triangulation of the Southern Trigon, also embracing much of Colonel Lambton's triangulation in Southern India, has been reduced to final terms, but a large amount still remains for treatment. Good progress has been made with the preparation of the new edition of the Auxiliary Tables for facilitating the calculations of the Department. The book, which will be published during the next few months, will be a much larger work than the old edition: those tables of which latitude is the *argument* have been extended for application from the equator to 40°, and many new tables and improvements have been introduced, which will largely extend the scope of its usefulness and render it a great boon to the Department and probably a valuable work of reference to others. Considerable assistance has been rendered to the two Astronomical Parties in bringing up their last season's work; and towards bringing up the arrears of the Khándesh Survey. Large help was given over a period of seven months to an officer, who had been exploring in foreign parts, in the reduction of his astronomical and meteorological observations. The remaining work of the computing section is of a miscellaneous character as will be seen on reference to the appendix.

80. (3) TYPE-PRINTING SECTION.—Professional Volume IVA., containing the reductions and details of the Jodhpore and Eastern Sind Meridional Series of the North-West Quadrilateral, has been completed and issued; so that the whole of the details of the *principal* triangulation of the North-West Quadrilateral have now been published. The Synoptical Volume of the Jodhpore and Eastern Sind Meridional Series is also in the press, but very little progress has been made owing to other work of a more pressing character. This is the last of the series of Synoptical Volumes of the North-West Quadrilateral. The Synoptical Volume XIIIA., containing the reductions and details of the South Párasnáth and the South Malúncha Meridional Series appertaining to the South-East Quadrilateral, was issued, which completes the publication of the whole of the principal and secondary triangulation of this Quadrilateral. The printing of the details of the principal triangulation included in the Southern Trigon is in hand, but has not been pushed on rapidly owing to the necessity for giving precedence to the Electro-longitude operations, the new addition of the Auxiliary Tables, and the Spirit-levelled Heights in the Bombay and Madras Presidencies;

of these, the first includes the work of seasons 1881-84, and is about two-thirds printed; it will probably form the next issued volume of the Professional series; the other two will be brought out within the next few months.

81. (4) DRAWING SECTION.—A detailed statement of the work done in this section is given in tabular form on page cxxx of the appendix.

82. A complete set of plotting scales (4, 8, 16 and 32 miles) for parallels 0° to 40° have been drawn and published on a card about 20 inches square: this, it is believed, will be found very useful in the projection of graticules.

83. (5) PHOTO-ZINCOGRAPHY.—The details of the work performed by this section during the year will be found in tabular form at page cxxxiv of the appendix, but some remarks appear necessary in explanation of the money value (R16,661-8) of the outturn for this year, as compared with that for 1884-85 (R26,672-13); the expenditure for 1885-86 being R17,922-10, as against R16,845-1 for the previous year. To make the value R16,661-8 of 1885-86 strictly comparable with the figures for the year previous, the following should be added to the former:—

	R
(*a*) For superintendence (not now included in value) . .	2,400
(*b*) For lower rates ordered to be charged from 1st April 1886	1,700
(*c*) For professional and office forms, the bulk of which are now done at Calcutta, and which were previously printed in this office at intervals when the map-printing work was slack	2,400
TOTAL .	6,500

But for the deficiencies noted as (*a*), (*b*), (*c*), the money value of maps, &c., turned out would have been R23,161-8, against an expenditure of R17,922-10. Endeavours will be made to find suitable work for the presses during spare intervals in place of the forms, so that next year, even with the reduced rates charged for our maps, &c., it is expected there will be a much more favourable comparison between expenditure and outturn.

84. Among the maps published by this section the following may be specially mentioned:—The final prints of 18 of the Nepal-Bengal Boundary Survey Sheets, as well as 4 sheets of the Mechi River Survey and 7 skeleton sheets of the Daling Lands Survey; Map of Jeypore and Environs in 8 sheets, printed in two colours: and the map of the country between Umballa and Delhi, of which no less than 2,250 copies were required by the Quartermaster General's Department within a limited time, for the Camp of Exercise.

85. The amount realized during the year and paid into the Treasury on account of maps sold is R663-7: and the value of the work done by this section for other departments is R5,583-7, as shown at page cxxxiii of the appendix.

86. (6) SOLAR-PHOTOGRAPHY.—Photographs of the sun for the Solar Physics Committee, South Kensington, have been continued daily throughout the year, except on 75 days when the sun was invisible. With the large photo-heliograph 115 pictures (12-inch) of the sun have been taken during the year, and with the smaller instrument 525 pictures (8-inch) have been taken. As stated in the Report for 1884-85, these latter are used for the measurement of the areas of spots and faculæ, while the former are specially suited for the study of the mottling or granular appearance of the normal photosphere and structure of the penumbra of the spots. From the Greenwich observations for 1884 just to hand it is gratifying to find that photographs of the sun taken in India on no fewer than 161 days were employed to supplement those taken at Greenwich, thus bringing up the available total for that year to 315 days.

87. The usual tables of working facts, percentages of daily visibility of the sun, and statements of cost will be found at page cxxxvi of the appendix. The cost of this section for the year under report was R9,820-13.

88. (7) METEOROLOGY.—Besides the usual tabulated results of the meteorological observations usually given, there will be found in the appendix a table giving the average rainfall to date in inches from 1st June to 30th September, deduced from 21 years' observations, 1866-86.

Explorations.—The account of the Trans-Himalayan explorations that have been made under the superintendence of the Deputy Surveyor-General, Trigonometrical Branch, is given in Part II of this Report.

Colonel Haig and Mr. Cole make special mention of the services rendered by Messrs. Wood, Wilson, Atkinson, Peychers, and McA'Fee, and by Babus Gunga Pershad, Shiv Nath Saha, and Shoshee Bhushan Shome; and report favourably on all the other assistants attached to the Trigonometrical Branch Office.

APPENDIX.

EXTRACTS

FROM

THE NARRATIVE REPORTS OF THE EXECUTIVE OFFICERS

IN CHARGE OF

SURVEY PARTIES AND OPERATIONS.

Extract from the Narrative Report of COLONEL A. PULLAN, S.C., *Deputy Superintendent, in charge Cutch Survey,—Season 1885-86.*

The country surveyed this season is generally sterile, mingled "Ran" and grass land, but here and there well cultivated spots occur, notably the oasis of Antarnes, a rich and well-watered village in the middle of the Ran. The little peninsula of Nagar Párkar is too stony and sandy to be productive.

The principal towns which fall in the season's work are:—

NAGAR, the principal town of Párkar, situated at the foot of a group of granite hills rising abruptly to a height of 1,100 feet above sea level. A *Mukhtyár* is resident here, and the place contains a hospital, post office and police barracks. Population 1,822.

SANTALPUR, the principal town of Chotar, situated on the edge of the Ran. The *Thanadar* of the district resides here. Population by last census 1,664.

ADESIR, the principal town of the small portion of Cutch proper, which is included in this season's work, has a population of 3,133. The *Thakur* is the most important of the Cutch *Bhayads*.

VARAHI, the head-quarters of the *Wahiwatdar* of the sub-taluka, is about 1¼ miles north of one of the mouths of the Banás River. It has a post office and jail and a population of 3,233.

SINGAM, with a population of 2,765, is a principal station of the salt preventive line, and has a Salt Inspector's bungalow, police barracks and post office.

The granite range of Kalinjar is the principal feature in the peninsula of Nagar Párkar, rising to a general height of 1,100 feet, and in abruptness of outline and rich warmth of colour affords a striking contrast to the trap and basalt of Cutch and Káthiáwár.

The few small hills in the other remaining sheets are of trap formation, but are insignificant and call for no special notice.

134568

Extract from the Narrative Report of LIEUTENANT-COLONEL D. C. ANDREW, S.C., *Deputy Superintendent, in charge Deccan Survey,—Season 1885-86.*

DESCRIPTION OF THE COUNTRY.

Towns.—The principal towns met with are Ratnagiri, Sangameshvar and Devrukh. Ratnagiri is the chief town of the district with a population of about 11,000 people; as the head-quarters of the Sub-division, it has buildings for all the various offices of the different officials, a nice Club, and a large Lunatic Asylum lately built, which it is proposed to make the principal one in the Presidency. This town has also been selected by the Imperial Government as the abode of Thebaw, the ex-king of Burma, who lives there with his two queens. To the north-west on a point jutting out into the sea is a large fortress, the origin of which is doubtful: in fact very little is known about Ratnagiri for certain, prior to its being taken over by the British in 1818. Sangameshvar can only be called a small village on the Shástri River, which of late years has considerably declined owing to the Kumbhárli Ghát road having turned the Deccan traffic to Bombay *viâ* Chiplún from it; again upon the destruction of the Mámlatdár's Court it was rebuilt at Devrukh, thus reducing its importance still more. Devrukh at present is a small village, consisting chiefly of Brahmins; it is healthily situated on a high plateau and shows signs of daily increasing importance. This is due to the new road that has been made connecting the Amba and Kumbhárli Ghát roads. A small bazar has also sprung up owing to all the traffic from the Koondee Ghát passing through this village to Sangameshvar. Also, houses for the head-quarters of the Sub-divisional, Revenue and Police Officers, Subordinate Judge and Executive Engineer have been built.

Rivers.—The Sávitri and Váshishti are the two largest rivers, on which small tugs ply in connection with Messrs. Shepherd and Company's coasting steamers, one running daily from Bánkot to Máhad and from Dábhol to Chiplún on the latter, the journey being of a most uninteresting nature, the scenery consisting of bare hills and low shelving muddy banks covered with mangrove or weeds; the appearance of these rivers varies considerably, in some places being nothing more than large ponds, whilst in others, the current is very strong, their courses also being most circuitous: this can be accounted for as they are formed from thousands of water-courses or hill torrents flowing down from the Sahyádri Range and falling into these large rivers which flow through this narrow strip of country until they empty themselves into the Arabian Sea. The waters of all the rivers are brackish, being affected by the tide for several miles inland. Besides the rivers above-mentioned, there are the Shástri Bhatya and Muchkundi, but these are not nearly so deep as the two before-mentioned, although a very large traffic in country boats of small draught is carried on between Sangameshvar and Jaygad on the Shástri—more so than on any of the others.

Brief Description of Features.—The country is about 40 miles in width, lying between the Sahyádri Range and Arabian Sea and consists of innumerable flat-topped hills varying in height from 200 to 800 feet, which have a monotonous appearance, as they are either bare or covered with rank grass that soon dries up after the rains; the hills are intersected by small valleys, dotted over with little hamlets and temples under clumps of large mango, jack and tamarind trees, and this is the only relief to the eye of the official who has to work in a tract destitute of all *shikar* or anything likely to lessen the dreariness of his leisure hours. The coast all along the sea has a steep, rocky appearance with several small bays, at the head of which, as a rule, villages are found peopled by fishermen, who earn their livelihood by bartering dry fish for grain; this they carry in their boats to the large towns on market days. At the mouths of the rivers or large creeks are bays sufficiently large to make harbours for small vessels, but unfortunately most of them are dangerous of navigation excepting in fair weather. The country is a very difficult one for survey operations owing to the features being so very irregular and intricate, consisting of innumerable steps and precipices, necessitating great care and accuracy to delineate correctly on paper.

Population.—The population chiefly consists of Maráthas and Brahmins, the latter being to a great extent well-to-do, whilst from the former, a large portion of the Bombay army is recruited, the best soldiers coming from this district. The ineligible, or undersized men, finding it impossible to support their families out of the produce of this impoverished country, have to gain a livelihood as labourers by going to Bombay, where thousands flock yearly. It is from this district that the labour supply of Bombay chiefly comes, it being estimated that over 100,000 men, women and children proceed there annually during the busy export season.

Climate.—The climate, although healthy, is moist and relaxing and very trying to those whose constitution requires a dry heat, particularly during the months of March, April and May, when the excessive heat makes survey work very harassing: the temperature in the shade sometimes exceeds 108° at midday, and this is intensified by the heat refracted from rocks, of which the country chiefly consists, and the glare from the hills. The rainfall is plentiful, varying from 100 to 110 inches along the coast, and increasing as you get nearer the Sahyádri Range.

Extract from Narrative Report of MR. J. NEWLAND, *Surveyor in charge Gujarát Survey, Season, 1885-86.*

The survey comprised Sheets 72, 73, 75, 4, parts of 47, 52, 53, and 54. Sheets 72 and 73 comprise parts of Baroda, Rádhanpur and Kánkrej States, and also a few petty States under the Pálanpur Agency. Rádhanpur State has an area of about 833 square miles, a population of 91,579 souls, or an average of 109·9 to the square mile. Its south-western extremity abuts on the Rann of Cutch, from which a considerable portion of the soil is said to have been reclaimed. Sandy and black soil are also met with which yield good crops of wheat, cotton and rape seed. The trade in these has been greatly stimulated by the opening of the Rajputana Railway. The crops are almost entirely dependent on the monsoon, irrigation being confined to the vicinity of streams, which are few.

Kánkrej State stretches for about 35 miles along both banks of the Banas River; it has an area of about 507 square miles, a population of 37,771 souls, or on an average of 74·5 to the square mile. The Banás runs through the district, and though during the hot weather its bed is usually dry, water is plentiful in most places from 30 to 40 feet below the surface. The soil, sandy in some places and black in others, yields the usual rain and irrigated cold-weather crops.

The general aspect of the country in Sheets 72 and 73 is that of a flat, open plain, whose blankness is only relieved by the few trees which shelter the villages. Owing to the scarcity of water in the country the necessity of excavating large tanks for storing the rainfall has been forced upon the people, so that one or more tanks are to be found in almost every village. Many have been dug at the cost of private individuals. These tanks invest the country with a charm for the European visitor, whose eye rests with pleasure on their cool depths in the midst of a thirsty land. A great number and variety of ducks and water-fowl are usually found on them. Two rivers, namely, the Banás and the Sarasvati, flow through these sheets in a south-westerly direction and lose themselves in the Rann. The breadth of the Banás varies from 800 yards to a mile and-a-half and is split up into numerous narrow channels which interlace in the sand, forming miniature islands, the latter producing rich crops of wheat, vegetables and melons. Close to the Banás the land is liable to be flooded, but the floods do not at furthest pass more than a mile from either bank. The principal towns are Radhanpur, with a population of 14,722, Sami, with 5,306 inhabitants and Thara with 2,114.

The town of Rádhanpur stands in a wide open plain, mostly under water during the rains. It is surrounded by a part-stone, part-brick loopholed wall, 15 feet high, 8 feet broad, and about two and-a-half miles round, with corner towers, eight bastioned gateways, outworks and a ditch now filled up. Against modern arms the wall gives little shelter, and it could easily be taken by escalade or battery; there is also, surrounded by a wall an inner fort or castle, called Rajghadi, where the Nawab lives. Except a wide and clean main street, the town roads, little better than lanes, are narrow and rather dirty. The water-supply, taken from tanks and wells becomes a little brackish in the hot weather. Though subject to very great extremes of heat and cold, the climate of Rádhanpur is, except in September and October, healthy. The town of Sami stands in a low plain under water during the rains. It is surrounded by a brick wall, about one and-a-half mile in circumference, 24 feet high and 12 wide, now partly in ruins. To the east is a strong stone and brick court, and on the west a building of Nuransha Pir, with a lake called the Pir Talao. Besides these, there is a mosque and the tombs of some of the Nawab's families. There are no other buildings of brick and cement. The houses are irregularly built and the streets narrow and dirty. There is no river in its vicinity, the supply of water being obtained from tanks and wells.

Sheet 75 comprises portions of Baroda and Pálanpur States. Pálanpur State has a total estimated area of about 8,000 square miles, a population of about 500,000 souls or 62·5 to the square mile. The general aspect of this sheet differs little from that described above towards the south, but in the northern half it is more sandy and undulating. South of the River Banás, which flows through the sheet from north-east to south-west, the soil is a clayey loam, varying in color from whitish-yellow to pale-red, resting on a sub-soil containing a considerable quantity of carbonate of lime, nodules of which are to be picked up in quantities along the banks of the river. In the neighbourhood of old Deesa the ground rises from the river in terrace-like fashion which seems to mark the periodic recessions of the water from their ancient bounds. Most of the villages have a patch of grazing land varying in extent from a few acres to two or three square miles according to their requirements. This land is in most cases overgrown with a dense jungle of stunted trees of sorts, which, besides fuel to the villagers, furnish food for the camel and goat, both of which animals abound. The inhabitants are mostly Koli Thakoras, of mixed Rajpoot and Koli origin who were the original proprietors of the soil and are still exempt from land-tax. Rabaris (shepherds) are also numerous and own great flocks and herds of sheep, goats, cattle and camels. The principal towns are Pálanpur, with a population of 17,547, old Deesa with a population of 3,828, and Kanodar with 3,426. The town of Pálanpur is surrounded by a brick and mortar wall from 17 to 20 feet high, 6 feet thick and about three miles round, with seven bastioned gateways, and at the corners, round towers, armed with guns. Though in fair repair, the defences are useless against the attack of a

modern army. The houses are irregular and closely packed, and, with few exceptions, the streets and lanes are narrow and dirty. It is the head-quarters of the Pálanpur Political Superintendency and the seat of the Chief or Diwan of the Pálanpur State,—a Musalman of the Jhalor family. The railway station of Pálanpur is the nearest one to the military cantonment of Deesa, which is eighteen miles distant in a westerly direction.

Sheet 4 comprises portions of Baroda, Ídar and Pálanpur States, and also parts of a few petty States under the MAHIKANTHA Agency. With the exception of a small portion in the north-east corner of the sheet, which is hilly and covered with scrub jungle, all the sheet is flat or slightly undulating, and tolerably well covered with fruit trees. The soil is for the most part sandy, with patches of rich black soil which allow of three crops being produced during the year. Grains of various sorts are produced, including a very superior description of rice. Large quantities of wheat and rape-seed are yearly taken away by the Rajputana Railway for exportation to England. The principal river in the sheet is the Sábarmati, which takes its rise in the Meywar hills and runs through the sheet in a southerly direction towards the Gulf of Cambay. A smaller river, called the Amerdeshi, crosses the north-west corner of the sheet on its way to the Kanu. This river gets quite dry during the summer months although water is always obtainable a few feet below the surface of the ground. The chief towns are Vadnagar, with a population of 15,424; Kherálu, with a population of 11,030; Umtu, population 5,805, and Sipor, with 5,643 inhabitants. Vadnagar is a very old town, said to have been founded in A.D. 144. The town, says Burgess, has produced many of the men who have played a prominent part in Gujarát. It is encompassed by a strong masonry wall, and, being on a rising ground, has a rather picturesque appearance; to the north-east is the large Sarmishta tank, of a circular shape with an island in the middle of it. The water is flanked with stone walls and steps; trees fringe it; and here and there a small temple has been erected; the houses of the town are often perched above the walls, and steep stone stairs, one numbering 360 steps, lead to the water. In the neighbourhood are the remains of Badshahi Bagh which commemorates the Musulman rule. Towards the north-east part of the sheet are situated the celebrated Jain temples of Shri Ajitnathji and Shambhavnathji—the resort of numercus pilgrims from all parts of India. The temples are on a hill which bears the name of Taringa, probably from a shrine that has long been there dedicated to a local deity Taran Mata. The temples are of no very great size, the enclosures measuring 250 feet round, and the temples 125 feet high. The main temple was built by Kumar Pal of Anhiloada about 1143-1174. The special times of pilgrimage are during the full moon in the months of November and April.

Extract from Narrative Report of LIEUTENANT H. M. JACKSON, R.E., *Officiating Deputy Superintendent, in charge Mysore Survey,—Season 1885-86.*

The portion of the Kolar District plane-tabled this field season is all that to the east of meridian 78°. It is generally undulating, partly covered with cultivation, partly with scrub jungle, in many places with nothing but stones. The valleys, of which the streams are mostly dammed so as to form lines of large tanks, hold rich fields, where rice and vegetables are largely grown. Almost everywhere, but chiefly on the bare ridges, are strewn masses of boulders of every shape, and around these generally a skirt of smaller rocks and stones. Here and there bare rocky hills rise, some suddenly from the plain, others with skirts of gravel and detritus rain-cut into numerous water-courses. Along the western edge of this tract runs a much broken line of hills, entering the district north of Gumnayakanpalya and trending nearly south, where it appears only at intervals in the peaks of Murugamale, Ambajidurga and Rahmandurga, thence again south near Kolar town, finally merging in the Tyakal hills and the *ghâts*. From the northern end of this range, flowing to the north-east rises the Vandaman River; and from near Ambajidurga, flowing south and west, the Palar supporting in its much-interrupted course a very flourishing cultivation. The Papaghini rising from under the skirts of Nundydroog, flows about north and west into the large tank of Vyasa Samudra and out through it to the north. There are also two smaller streams, affluents of the Pinakini to the south, which rise from either side of the southern portion of this range and flow out of the district, the one nearly due south, the other south-east, and then south; their names are doubtful.

A line of low hills rises near Shrinivaspur, and running fairly parallel with the first described passes to the east of Kolar and southwards to the *ghâts*. Still more to the east are several groups of hills, irregular in formation, sub-buttresses of the Mysore plateau, in some instances enclosing elevated valleys. The central and eastern parts of the country in question, valleys of the Palar and Papaghini, are undulating and well cultivated. The northern, western and southern portions are more broken up by the hills just detailed, and less fertile. The third range of low hills mentioned above consists of clayey slate with veins of quartz, in which is found the gold worked to a considerable extent in olden times, and again recently the object of much busy enterprise.

In the south-east corner of the Betmangala *taluk* is a patch of small tree jungle, and clumps of acacias are common; but, generally, where the land has remained uncultivated, if there is any vegetation at all, it is merely bush.

The revenue of the Kolar District generally has been increasing steadily. The latest "Mysore Administration Report" shows it to be about R 10,55,955.

The means of communication may be said to be generally good. The following roads cross this part of the country :—

No. of sheet.	Name of road.	Imperial.	District.	Remarks.
70	Dadahalli, Yelandur . . .	...	District.	
„	Chamrajnagar, Hasnur . . .	Imperial.		
43 & 44	Bagenhalli, Chelur	...	Do. .	Under construction.
44 & 45	Hookote, Madanepalli . . .	...	Do.	
45	Bagenhalli, Chintamani . .	...	Do.	
45 & 46	Sidlagatta *viá* Shrinivaspur to Mulbagal	...	Do.	
45, 46 & 66	Bowringpet *viá* Kolar and Shrinivaspur to Targol	...	Do.	
46	Jangamkote *viá* Kolar and Betmangala to Venkatgiri Kote . . .	...	Do.	
46	Hoskote *viá* Kolar and Mulbagal to Chittur	Imperial.		
46	Mulur, Narsapur , ...	...	Do. .	Ditto.
46	Malur, Kolar	...	Do.	
46 & 66	Bowringpet *viá* Betmangala to Mulbagal	...	Do.	
66	Malur Barki	...	Do.	
66	Bowringpet, Budikote . . .	...	Do.	
66	Ditto *viá* Gold Mines to Kansandra	...	Do. .	This road is in use, but is not quite constructed.
66	Kansandra to Fuel Forest . . .	...	Do. .	Under construction.
65	Kankanhalli to Kodihalli . . .	...	Do. .	Ditto.

Fairs are held at the towns detailed in the following list arranged in order of importance, *viz.* :—

Kolar, Bowringpet, Mulbagal, Chintamani, Shrinivaspur, Kyasamballi, Kamsandra, Budikote, Masti, Narsápur, Vemgal, Vakkaleri, Sugatur, Somayajalpalli, Nelavanki, Yallur, Ryálpád, Adgal, Betmangala, Tailur, Utnur, Bairkur, Malinaikanhalli, Bilur, Pichpalli, Uriga, Forlakki, Tádigol, Yerkálve, Bhairganpalli, Nangali, Pulagal, Korlaparti, Pályakeri, Batlahalli, Tambihalli and Mittur.

There are no remarkable hill forts in this part of the district, except that of Ambajidurga, built by Tippu Sultan. In some of the old Palagar *jagirs*, however, to the north and east there are still to be seen a few remains of their robber strongholds.

The country comprised in Sheet 70, consists mostly of the Yelandur Jagir, held now by Krishna Murti, the grandson of the Minister Purnaiya, to whom the grant was originally made. The low lands of the *jagir*, watered by the Suramavati and Honnu Hole and the tanks that these streams feed, are among the most fertile rice-lands in Mysore. One-third of their area is held by Brahmans. Besides rice, much sugar-cane is also grown.

The temple of Billigiriranganbetta, about 4 miles from the town of Yelandur, attracts numerous worshippers The temple itself is in a poor style, but it is imposingly situated on the edge of a precipice crowning a hill that rises about 2,000 feet from the plain. The approach is by rough stone steps, so disposed as to render the ascent more difficult than it would be without them. Near the temple is a plantation kept up by the *jagirdar*, in which coffee cultivation has been attempted with but poor success and is now giving place to cinchona and tea: most excellent fruit is grown here.

In these hills are several settlements of the Sholegars. They are of apparently "Non-Aryan" race, live invariably in the jungles in lean-to's or in bamboo huts, in the middle of little temporary clearings, in which they grow their scanty supply of *ragi*, to be supplemented in the dry season by roots, and at all times by the wild honey which they are very clever in finding. By this indeed, and by finding different gums and lacs of certain market value they manage to clothe themselves, unless they earn pay for odd jobs from forest officer or planter. But they are an independent race, preferring to do things in their own time and way, and they are too conservative in disposition to accept the benefits of the civilization around them. They are skilful trackers, but are by no means courageous, and towards the elephant and tiger they evince the profoundest respect.

Extract from the Narrative Report of Lieutenant W. H. Pollen, R.E., *Officiating Deputy Superintendent, in charge Rajputana Survey,—Season 1885-86.*

With regard to the nature of the country triangulated in Degree Sheet VII, the ground in the south-east is level, with sand-hills. Towards the west there are rocks and rocky hills, some running up to 1,200 feet above the sea. In the north-east is a plateau some 600 or 700 feet above the sea and 100 feet above the general surrounding level: the surface of this plateau is pebbly and covered with *karil* (*capparis aphylla*) jungle; in it is a large depression, about 6 miles long and 1 wide, the surface of which is encrusted with

salt. In the south-east the water was not good and had to be taken from the *pakka* cisterns (*tanke*) near the villages.

The northern part of Degree Sheet VI is sandy with high sand-hills (*dhure*), and the water is generally bad. In this portion, too, there are hardly any villages, but numerous collections of huts (*dhani*), which are used by the cultivators in the rainy season and are deserted at other times. At Ramdera, about 6 miles north of Pokaran, there is a large annual fair. Some two years ago there was great mortality from cholera there, and the ground is strewn with human skeletons. In the south the ground is hard and rocky. At Loharki there are some stone quarries, and at Bhadra in the south-west a small fair is annually held.

As regards the country surveyed in detail, the River Lúni runs through the east portion of Degree Sheet VIII. In the north-east the ground is level, with sand hills; and in the north-west there are rocky hills running up to over 2,000 feet above the sea. There is a curious out-crop of rock running up from Kalinjar in Cutch, to the north of Jeysulmere; it appears in the west portion of the sheet. On each side of the Lúni is the *nayar* land, an alluvial soil brought down by the river. This land is 14 miles in width near the Ran of Cutch.

The sand hills rise to about 100 feet above the surrounding country. The water in the western portion is generally good in the wells, but towards the east, among the *dhure*, the water is mostly brackish even in the wells. The country is covered with *dhuni*, every house has perhaps 2 or 3 *tanke*, circular cisterns 8 to 10 feet in diameter and 10 to 12 feet deep, lined with *chunam*, for storing rain-water. The water is good when boiled, but the inhabitants do not like parting with it.

There are no forts in the country surveyed, though it has been the scene of much lawlessness in earlier years.

The chief towns are :—

Balmer or Bármer—the head-quarters of the district; Maláni—where a *hakim* resides, built on the slope of a hill; Guranagar on the Lúni—the chief of this place has a remarkably fine breed of horses—and Sindri on the Lúni.

There are some clusters of hills near Bármer of igneous rock. The largest hills are those of Jesai and Taratra, of both of which the slopes are very steep. There is an easy pass in the hills between Geu and Drura villages, the road is hard and good, and there is only an ascent of some 50 feet. The chief roads are from Bármer north to Jeysulmere, *viâ* Jalipa, Kapuri and Bharko. Also from Bármer south to Sachor, crossing the Lúni at Chitalwána. The only river worth notice is the Lúni, in the bed of which pools of brackish water are frequently met with during the cold weather; by digging a few feet down in the bed, however, good fresh water is obtained, but during the rains the river water is undrinkable. The inhabitants are chiefly Rajputs: there are no Bhils, but there is a proportion of Jat cultivators. They have fine herds of cattle, sheep, &c., and good camels. There is a sprinkling of Mahomedans, some Sindis and some Baluchis, locally known as "Sarhai." The land produces *bajra* in all parts, and wheat in the *nayar* land on the Lúni. There are some villages occupied by the *Mali* caste, who cultivate vegetables, such as radishes, onions, pepper, &c., and tobacco.

Fuller's-earth is found in parts.

The soil generally is sandy, with the exception of the *nayar* land, which is black and fertile.

Report by MR. G. P. TATE, *Assistant Surveyor, Rajputana Survey.*

The country triangulated during the past season comprises Sheets 43 and 58 of Central India and Rajputana, and consists of a part of the Sáchor Pargana of Marwar or the Jodhpore State, and the northern portions of the territories of petty chiefs of Tharád and Váv, both of which are under the orders of the Political Agent of Pálanpur, and lie on the northern boundary of Gujarát. The chief of Tharád, and the Rájput landholders are a remnant of the Bhagela dynasty which succeeded, in 1193, the Chaluk or Solanki clan in Anhilwára Pátan.

The chief of Váv is descended from the Nadol branch of the Chauhán clan, which, in ancient times, had extended its several branches from Delhi and Hariána in the north to Golconda (in the Nizám's dominions) in the south; and from Chotan in the Bármer desert in the west to the plateau of Meywar in the east. Sáchor, according to the traditions of the local bards, was the possession of the Kálam, or Kálma Rájputs. This tradition is verified by the translation of a part of an old record of the early Kings of Chitor, contained in the "Annals of Rajputana," by Colonel Todd: in which the "Kálam from Sáchor" is mentioned as one of the allies of the King of Chitor, who had summoned his adherents to resist an invasion of the Mahomedans from Khorasan. The date of the above-mentioned record lies between 824 and 836 A.D. The date of the acquisition of Sáchor by the Chauháns could not be obtained even approximately; but the exploit of the Chauhán chiefs, Apa and Vikran, who introduced their retainers in disguise into the stronghold of the Kálam chief on the occasion of a marriage festival, affords a theme for the bards, who wander from village to village, and gain a livelihood by recounting the achievements of heroes of ancient

days. These bards are the possessors of all the genealogies and traditions of the country, oral as well as recorded. Sáchor was acquired by the Ráhtor Princes of Jodhpore over 100 years ago, since when it has been one of the *parganas* of that State. The Ráo of Chitalwána, who has a *jagir* (free-hold grant) on the banks of the Lúni, about 15 or 20 miles north and north-west of Sáchor, is a descendant of the last of the Chauhán Ráos of that place. Sáchor is a well built village of considerable size, and possesses a post office and dispensary. The mails are sent from the Cantonment of Deesa about 60 miles to the south-east.

Dhárnidar, about 20 miles south by west of Sáchor, is a large village of the Váv Pargana, and contains a shrine, which is visited by Hindu pilgrims. A battle was fought near this village between the forces of the Jodhpore Rája Bhím Singh and those of the Amir of Hyderabad, in which the latter were defeated.

At Batki, about 20 miles west of Sáchor and near the Ran of Cutch, is a station of the Northern India Salt Revenue Department, two officers of which and a subordinate establishment are stationed there.

The surface of the country triangulated consists of gentle undulations, and as it is nearly all under cultivation, and has numerous villages, each surrounded by large trees, a reconnaissance had to be effected before the observations could be commenced.

The soil is sandy; but water is not at a great depth from the surface, and is generally good. The crops are entirely dependent on the rainfall, and nothing which requires irrigation is cultivated. An area of about 180 square miles of the Ran of Cutch was included in the triangulation.

The word "Ran" is a modification of a Sanskrit word and means a swamp or depressed plain: it is frequently met with in Western Rajputana, where any depressed plain is called a Ran which during the rains is flooded, and where, after the accumulated waters have evaporated, there is an efflorescence of saline matter. One of these Rans occurs about 30 miles north-west of Bármer, and it is said that Pokaran, a large and important town of Jodhpore on the borders of Jeysulmere, takes its name from five such depressions which unite at or near the site of the town. The Lúni River flows through a strip of alluvial soil which is sometimes under a mile in width and at others as much as 10 or 12, and falls into the Ran of Cutch about 2 or 3 miles south of the Trigonometrical Survey station of Akoria, of the Karáchi Longitudinal Series. The Lúni bifurcates at about 30 miles from the Ran, the main branch flowing about 100 yards to the west of Akoria station.

During the cold weather the surface of the Ran is a glittering expanse of white salt, forming a crust about 3 inches in thickness, under which lies the briny ooze of the swamp. At this time of the year it is capable of affording a passage to foot passengers, and there is one well-known foot-path which crosses diagonally from the village of Kandalia on the eastern shore to that of Churia at the foot of the Vorawa hill on the west. Near the shore the salt crust can support a man easily, and horses and even camels in some places. During the rains, when the Ran is flooded, it is impassable. The course of the waters of the Lúni can be traced for some distance by the deposit of mud, which being mixed with the salt, is of a dark-grey color. It is said that the annual deposit of mud is encroaching on the salt. Just south of the spot where the main branch of the Lúni falls into the Ran, there are small islands of saline earth, distant from the northern shore about 3 to 6 miles. On one of these islands, about 6 miles south of Akoria, a station was selected, and reciprocal vertical angles were observed for determining its height. The platform is flush with the level of the island.

The islands near the shore are covered with tamarisk and the *Salsola* plant. The latter resembles the *Portulacca* in appearance and is very plentiful along the margin of the Ran. It is known locally as the "*Saji*" plant. The color of the *salsola* is a dark brown.

The salt is not fit for use immediately it is taken out of the Ran. It consists of about 96 per cent. of pure salt, about 3 per cent. of chloride of magnesia, and the balance of other foreign matter. Looking across the salt deposit beyond a distance of 2 or 3 miles, the white salt seems to be lost in what appears to the eye to be an expanse of blue water; and to make the illusion complete, the rocky hills towards the west and the higher sand hills on the western shore appear as islands in a vast sheet of water. This is also noticeable in the broad grassy plains to the north of the Ran. Small bushes are magnified to the size of trees and appear as wooded islets, and as trees fringing large sheets of water.

The margin of the Ran, where the sand hills do not come down to it, is covered with a grass, locally known as "*Mottra*," which resembles that well-known variety "*Dub*" in the way it grows. The root is a small bulb, about $\frac{1}{15}$th or $\frac{1}{10}$th of an inch in diameter, and is eaten by the poorer classes.

At the commencement of the summer when evaporation increases, the fish inhabiting the large pools of water which remain in the bed of the Lúni, die and float to the shore in large numbers; for the pools then become merely large salt pans. Fresh water can be obtained along the edges of the Ran by digging holes a few feet deep.

On the north-west of the Ran the sand hills come right down to the shore, and are fairly well covered with *Komta* jungle. The *Komta* is a thorny tree with white bark, and grows to a height of 20 to 25 feet. This part of the country has a very desolate appearance. There is fairly good shooting about the Ran, and to the east of it are to be found floriken, bustard (great and lesser), sand-grouse, partridge, hare, *chinkara*, or ravine deer and black buck.

Extract from the Narrative Report of LIEUTENANT F. B. LONGE, R.E., *Officiating Deputy Superintendent, in charge South Marátha Survey,—Season 1885-86.*

The country surveyed was of a most varied description. There are the forest-clad *ghâts* on the west and the densely-wooded country south of Khánápur, then the quartzite plateau to the north of the Belgaum Valley, thickly covered with thorny bushes, and at Murgod again flat hills of conglomerate overlying quartzite beds, and covered in parts with cactus bushes, as well as large open tracts of grass land and country suitable for dry crops. The geology of the district, as well as all other information, is most fully given in the Belgaum Gazetteer.

In the hilly west, the rugged hills, the ravines and the abundance of trees and brushwood render the country interesting and beautiful. The upper slopes and scarps, which are of trap, resemble those of the Bor and Tal passes in Thána, and the scarps are so high and continuous that the country presents great difficulties to the surveyor, who often has to go miles to reach a spot not more than a few hundred yards from him in a direct line. Each village in the *ghâts* has a little watered rice land, on which two crops of red rice are grown yearly. In the hot weather, there is not much water except low down in the valleys, and in one or two of the bigger streams, in which the water is banked up at intervals and the intermediate space is sown with rice. In February, the trees are almost bare and the grass is bleached or burnt—a few *ráis* or sacred groves, as for instance that of Parli in Sheet 243, alone relieve the general barren appearance. These *ráis* are evergreen and in many cases are almost impenetrable. In May, after a few showers, the country begins to freshen up wonderfully, the grass soon appears, and everything seems to take a fresh lease of life. Eastwards, towards Belgaum, the valleys become flatter, broader and more suited for tillage, while near Belgaum itself are large tracts of undulating grass land on which flocks of goats and sheep are reared.

The Belgaum District may be said to be divided into three belts,—by the Malprabha River in the south, the Ghatprabha in the centre, and the Krishna in the north. The latter area does not concern us, as it lies far north of the scene of operations this year, and only a portion of the middle belt falls within the area allotted for survey to this party.

The hills north and east of Belgaum form the water-shed of the Ghatprabha and Malprabha Valleys, those to the north from Kákti towards Nésargi, are scarped and covered with thorny bushes; further east they are replaced by comparatively low sandstone ranges, while at Murgod in the extreme east of the country topographically surveyed this year, the hills rise again abruptly to the height of some 250 to 320 feet above the surrounding country, and are chiefly composed of conglomerates, with sandstone overlying a bed of quartzite, forming a largish plateau, greatly broken by weathering and covered in places with cactus bushes, in which partridges, quail and hares abound. There is also a tank in the hills near Murgod, to which grouse in very large numbers betake themselves every morning to drink. The rest of the country south of this is open grass or cultivated land, (the product being chiefly cotton) more or less undulating, while in Sheet 276, the country is much more broken and is fairly covered with forest. The hills near Khánápur are rugged, high and of striking outline, and the forests thence southwards and to the west are admirably placed for supplying fuel to the Southern Marátha Railway which runs through this portion of the district.

The chief towns and places of interest falling within the area surveyed this season are :—

Belgaum.—The head-quarters of a brigade,—consisting of 3 regiments of infantry, 1 battery of artillery—and also of the district, is a pretty station well-wooded and situated at an altitude of from 2,100 to 2,260 feet above, and 50 miles from, the sea, with a population of about 25,000 souls. The town stands on one of the laterite hills which form the eastern slope of the Márkándeya River which flows south-west to north-east, about 3 miles, and of its feeder, the Belari, which is about 2 miles south of Belgaum. The city is situated between the British infantry and artillery lines, and the fort, while to the south-west, are the Native infantry lines. About half a mile to the south is the town of Sháhápur belonging to the Sángli State. Water is obtained entirely from wells, which afford a plentiful supply throughout the year, but in Sháhápur the water is brackish and unpalatable. The roads are numerous and good.

The fort of Belgaum, which is about 1½ miles in circumference, is surrounded by a wall about 35 feet high, pierced by two gateways, one protected by a large outwork. Round the wall is a deep ditch, about 70 feet wide, which, except during the hot weather, is generally full of water. The fort is kept in a fair state of repair and contains an arsenal depôt, a church, some barracks, and a number of private houses surrounded by gardens: it is well-wooded and has an ample water-supply from wells.

Belgaum is an old town, and is called Venugram, or the Bamboo Village, in inscriptions of the twelfth and thirteenth centuries. The fort is said to have been built by a Jain king, and both it and the town appear to have often changed hands. In 1472 the fort was captured after a vigorous defence by one Mujahid Shah Bahmani. About 1488 it was seized by the Governor of the Konkan Bahádur Gilâni. In 1498 it was assigned to Bijápur, and in March 1510 the Hindus rose and driving out the garrison resumed their former allegiance to the Vijaynagar kings. In 1511 it was granted to a Persian named Khosru Turk as a reward for saving the young king Ismail Adil Shah from the treachery of his guardian, and he reigned under the title of Asod Khan till 1549,

during which he was the mainstay of the Bijápur power. His is the greatest name in Belgaum history, and he is looked upon as a saint whose power keeps cholera from the place. There were many attempts to wrest his power from him but he frustrated them all and eventually died at Manoli, 3 miles south-west of Belgaum in 1549, and was succeeded by his son. In 1593 Ismail, brother of the Bijápur king, possessed himself of the fort; but though he withstood a siege, he was eventually induced to march on Bijapur and was captured and shortly afterwards put to death. In 1673 Shivaji, on his way to Hubli plundered Belgaum. In the third Marátha war in 1818, Munro attacked Belgaum on 22nd March having arrived on the 14th, and on the 11th April a practicable breach having been made, the garrison surrendered and were allowed to march out with their arms and private property.

Khánápur.—Situated on the Malprabha River at the point of crossing of the Southern Marátha Railway, is the head-quarters of the *taluka* of that name. It has revenue, police, and post offices, a rest-house, &c. It has a small trade in rice and plantains. It was formerly, in about 1720, a large entrepôt for Goa merchants who exchanged drugs, China goods, metals and spices for cotton and saltpetre with the Hubli, Nargund and Navalgund merchants: this trade was afterwards removed.

Nandgad.—A village 7 miles south-east of Khánápur, with a population of some 9,000 or 10,000 souls, a post office, weekly market and three schools.

Bidi.—Formerly the head-quarters of a sub-division, afterwards transferred to Khánápur.

Murgod.—About 15 miles north-west of Saundatti has a fair trade in cotton and grains. There are revenue, police and post offices and a Canarese school. It has a yearly fair lasting six days, in November—December; the village is partly enclosed by a wall and ditch, now ruined, and in rear by hills. There is a ravine about half a mile from the village, frequented by panther, and I had a shot at one within 50 yards of the village in the dusk of the evening last February.

Nésargi.—On the Belgaum-Kaládgi road, about 7 miles north of Sampgaon, has a dâk bungalow. It has a weekly market on Monday, and weaving and bangle-making industries.

Sampgaon.—The head-quarters of a *taluka*, has the usual offices, a post office and two schools. There is a weekly market on Sundays, where cattle, grain, cotton and cloth are sold. The first mention of Sampgaon is in 1683 when Aurangzeb's son, Mahomed Muazzam, is mentioned as besieging and capturing the fort after a gallant attack. It lapsed to Government after the Kittúr outbreak in 1824.

Halshi.—An old town about 10 miles south-east of Khánápur, the chief capital of the early Kadambas (A.D. 500); it has no trade or manufactures. It has three large temples, two of which are in the town,—one to Varáhvarsinh and the other to Suvarneslvar.

Mugatkhán Hubli.—Is a large village on the Dhárwár road, 18 miles south-east of Belgaum; it has a travellers' bungalow. It is so called after a Bijápur officer, named Mugat Khán whose tomb is in the village.

Kittúr.—On the Belgaum-Dhárwár road, is a large village with a ruined fort and citadel. An inscription of about the close of the twelfth century is the earliest known mention of Kittúr. In 1785 Tipu seized Kittúr and placed a strong Mysore detachment there, which held out against Holkar with a large force for more than a month, when the siege was raised. Tipu in 1787 handed the place over to the Maráthas. Under the treaty of Seringapatam, Kittúr became again a part of the Marátha country.

The Duke of Wellington (then General Wellesley) in his pursuit of Dhundia Vágh in 1800, reached Kittúr on 5th August and was delayed for six days, making boats to cross the Malprabha. Subsequently Mr. Mackray, the Collector at Dhárwár, sent by Government in 1824, to take charge of the Kittúr Estate, was murdered, and his two assistants were imprisoned. The place was invested in November and the prisoners released, the garrison surrendering at discretion. The State thus lapsed to Government.

In 1828 Kittúr fort is described as being a heap of ruins but still worth seeing, as the ruins showed it to have been a place of great strength.

The chief hill forts and hills of special mark in the area surveyed during the season under review are:—

Yellurgad.—A ruined fort at the west end of a high trap ridge, about 7 miles south-east of Belgaum. It is 3,288 feet above sea-level. This hill and fort are the most conspicuous objects in the neighbourhood of Belgaum.

Shamshergad.—Once a fine old fort, is situated near the apex and on the highest part of a sort of V shaped ridge; its altitude is 3,001 feet above sea-level and about 700 feet above the plain. It was built of stone and earth, but now is quite ruined. The spurs springing from it run north-east and east for about 3½ to 3 miles, and at their feet are the town of Nandgad and the village of Bijgarni. There is a well and a good mango grove in the fort. The ascent is easy from the east.

Máchigad.—A small fort above the village of Bijgarni.

Kalánidhigad and Gándharvagad, both hill forts, fell within the area surveyed this year, but as the sheet is not complete, they will be described in next year's Report.

The Malprabha River—rises in the eastern spurs of the Sahyádri range, about 8 miles west of Jámboti in Khánápur. Of the origin of the river the following story is told:—

In Kankumbi, on the eastern slope of the Sahyádris, lived a man, with a beautiful and virtuous wife. In spite of her goodness, he was jealous, and gave her neither rest nor

peace. At length driven to despair, she sacrificed to the gods, and offering a prayer to Basava, the patron of the Lingayats, threw herself into a mountain tarn. The pool on receiving this sacrifice overflowed its banks and formed a river which was called Malprabha or Malápahari "the cleanser from sin."

From its source it runs east for some 13 miles, when it turns south-east for 8 miles and then to the north-east past Khánápur and Lokodi. Though shallow, its flow is continuous throughout the year. The chief ferries in the portion of its course under review are at Khánápur, Mugatkhán Hubli—Turmuri—Sángoli and Virapur.

The Malprabha, entering Sheet 276 at the village of Mansápur, is joined at Lakhibail by the Chor Nala, an inconsiderable stream; close by at Kodchivad it receives the waters of the Khumbar Nala, which drains a largish area rising as it does in the hills near Kánvikarvinkop in Sheet 275 S. W., and further on it is joined from the north by a large *nala* rising in the hills near Siddanbhavi and Basápur in Sheet 275, and from the south by the Satti Nala, also a biggish stream which has a large drainage area rising as it does in the hills near Nandgad, of which Shamshergad is the highest, flowing south-west past Halshi near which it bends north-east to Bidi, and, continuing in this course, flows past Kasmalgi and Chikangroli to the Malprabha.

A fairly large *nala* flows into the Malprabha at Hira Mulkur, and the next important one is the Dod Nala which rises near Shigihalli and flows past Belvadi and Lingadhalli and joins the Malprabha at Budihal. From the north the Kiadgi joins it at Vakund rising near Hongal.

In Sheet 275 the Hira Nala rises in the hills near Sutgatti, and flows north-east past Nésargi and Chik Badnur, and so out of the season's work.

The Bándan, which rises in this sheet near Harngop, flows through Markumbi, where it is joined by the Bagnáth Nala, and eventually meets the Chilár Nala at Chikkop and the three combined flow into the Malprabha River at Ingalgi.

The Márkándeya River which rises in the hills near Bailur in Sheet 243 and enters Sheet 275 at the village of Ambevádi is a biggish stream and flows north-west past the villages of Alitgi and Honga, where it enters the hills and continues its course east by north through the hills, widening as it goes past Kenchanhatti, and so out of the work; it eventually flows into the Ghatprabha at Gokák.

The Mogitar Nala and one which joins the Malprabha at Khánápur are the only other streams of importance in the country under report.

The Hari Nala rises in the hills south of Belgaum, of which Yellurgad is the highest point—flows in an easterly direction past Marikatti, Tigdi and Sampgaon, whence turning in a south-easterly direction it flows past Naginhál and so on to the Malprabha. At Naginhál it is joined by a biggish *nala* from the north.

Sheet 243 not having been completely surveyed, is not reported on, as no maps are submitted this season.

The Belgaum District is well known to be particularly well supplied in the way of roads.

From Belgaum as a centre, made roads run to Poona on the north; eastwards *viâ* Aukalgi to Gokák and through Nésargi to Kaládgi; south-east, through Bágevádi to Dhárwár and a branch from Bágevádi to Murgod, and so on to the Kaládgi road; southwards to Khánápur and thence to Canara and south-west to Jámboti, leaving the Khánápur road near Yalúr, and westwards to Chandgad, Amboli, and so on to Sávantvádi.

The Southern Marátha Railway from Poona runs through the work, entering Sheet 275 at the village of Budihal, it runs to Belgaum with a station at Kangaon and from Belgaum through Yalúr to Khánápur, and thence on to Londa, where it joins the Dhárwár-Goa branch.

There are numerous cart-roads throughout the distrtict.

Extract from the Narrative Report of MR. H. HÖRST, *Deputy Superintendent, in charge Burma Forest Survey,—Season 1885-86.*

In order to show why the out-turn was so small in comparison with the previous season's, it will be as well to remark that, the field season closed 25 days ealier than usual, and that the work met with several serious interruptions. On the 24th January, owing to the disturbed state of the country, particularly that of the reserved forest tracts in which two large bands of dacoits had been plundering the Karen villages, the detail surveyors had to be withdrawn from the Yoma, and fresh work allotted to them on the 2-inch scale. More than a week was thus lost in plotting fresh boards, in marching to new ground, and making fresh arrangements. During February the work was interrupted on two occasions by dacoits, and the aggregate number of days lost was 126. During March the Tharrawaddy and Prome Districts were more or less disturbed, and it was considered unsafe to allow small parties to work on the higher hills. Of the two, the Tharrawaddy District was most disturbed, and troops were placed at most of the stations on the Irrawaddy line of railway. In April matters came to a crisis: both districts were infested with dacoits, and it was positively dangerous to move about beyond a strip of country 5 miles wide on either side of the railway. The Local Government was then urgently solicited by telegram to permit the recall of the party from the field; but the sanction did not reach

till four days after. Meanwhile a large gang of dacoits, estimated at from 300 to 400 strong, was driven by the troops from Zigon into the ground which was under survey. The result was that three Sub-surveyors, with 40 *klassies*, narrowly escaped being massacred at Nyoung-le-bin, and Mr. Gibson's camp was attacked at Peinzaik on the 26th April. Four men fell into the hands of the dacoits who tortured them to death in the most barbarous manner, a fifth man was never heard of again and it is believed he too was killed. The loss of both Government and private property was considerable; Mr. Gibson and a Sub-surveyor escaped only with the clothes they wore, through their knowledge of the ground which was intricate and covered with jungle, and the work was abruptly brought to a close and several gaps were therefore unfortunately left. The Traverse and Triangulation Sections were similarly retarded although no casualties occurred, but Mr. Wilson had a very narrow escape and so had Mr. Ewing. The work was further retarded by the transfer of two good Sub-surveyors to Mandalay early in April and by an unusually unhealthy season, during which Mr. Wilson and several Sub-surveyors (one of whom was sent away to India on departmental leave early in March) suffered much from malarious fever.

The following forests are comprised in the area traversed and triangulated:—South Naweng, Middle Naweng, Gwaicho, Quaimeedo, Nabai-byo, Chaung-zouk, Pwaygin, and Shwelaung. The South Naweng is drained by the Taung-Naweng Chaung At the south-east portion of this forest is a large Karen area containing two *Tes* or hamlets, Nashi-te at the north on the Litwa Chaung and Nga-to-te, about the middle of the area, on the Taung-Naweng Chaung. Through this tract a fair road runs from Prome to Toungoo, *viâ* Paukkaung and Taungle. From the latter village it goes to Satbyu village, then along the Kyoukgyi Chaung and up the Litwa Chaung to Nashi-te, thence across the Yoma to Shwe-ye-te in the Toungoo District. In the Middle Naweng Forest, which is drained by the Alay Naweng Chaung, there are no Karen areas, nor are there any passes into Toungoo. There is a difficult path passing from Nashi-te to Dabi-te in North Naweng. The other forests contain no Karen areas, nor are there any paths passing through, save one from Paukkaung *viâ* Kadin-gna-sin and Bambwe Taung to Kangyin *thana*. The isolated forests of Nyoung-Ben-det and Htonyea were also traversed. The former lies about 10 miles south of Paukkaung and the latter about 8 miles north of Prome. The Fuel Reserves of Sinmizwé and Pauktaw close by the railway line were also traversed.

The country surveyed on the 4-inch scale had the Pegu Yoma range running through it, but the backbone of the range from which the drainage flows east and west is not a very marked feature. There are other parallel ridges and spurs of considerably greater elevation than the main ridge or watershed, which are very striking at first. The features are generally small and the labor of surveying them very great in consequence of the heavy jungle. With the exception of a few Karen *Tes*, which were burnt down by dacoits, the country is totally uninhabited, which is probably the reason why the detail surveyors were not more frequently molested by dacoits. The country surveyed on the 2-inch scale consisted of low intricate hills covered with dense jungle which retarded the progress of the plane-tablers quite as much as that in the reserved forests.

The principal streams met with were the Taungnyo, with the Thayet, Panyo-gyi, Mwe-gyi, Kyauk-Myaung, Sinzwé, as tributaries; and the Shwelé with the Le-zé and Peinzaik as its tributaries.

The following forest reserves were taken up:—Taungnyo, Bwet, Sha-baung, Kadin-zauk, Padin-ben, Tapun, Pazingye, Kanni, Nyanle, Shwele, Kyauk-kyi-Taung, Padit Myaung, Kyibyu, Inma-Tayokmaw, as well as 5 interlying or adjacent Karen areas.

Routes.—From Paungdé in the Prome District *viâ* Tantabin, Nyounghla and Nyoung-le-bin to Ngapan-te in the Toungoo District, 6 marches. First march to Tantabin, where there are 5 *pakka* wells, 15 miles, a good cart track; second march to Nyounghla, 8 miles, cart track traversing low hills and along the Taungnyo Chaung for 1½ miles near Nyounghla; third march to Nyoung-le-bin, 10 miles, village of Thumba-di half way, road crosses Taungnyo Chaung, a fair cart road in dry weather. From Nyoung-le-bin there is only a footpath practicable for elephants lightly laden. For about half a mile the path runs along the bed of the Taungnyo Chaung, skirts the Maung-de Chaung for 1½ miles, crosses a low hill and again follows course of Maung-de Chaung ascending afterwards Sobyu Taung ridge 880 feet. From this point a succession of ridges and streams have to be crossed till the Yoma is reached near the hill, called Makupya. The descent on the eastern face of the Yoma is gradual, and the path, after keeping along the Yoma ridge for a short distance, runs along a stream till Nga-pan-te is reached; distance about 24 miles, 3 marches, with water at the halting places; no supplies procurable anywhere.

From Paungdé (Prome) to Aunghla-te (Toungoo), four marches.

First stage Ngapaw, a *thana* and large village; by a good cart track 16 miles; second march to Peinzaik, 11 miles; a small village with little water; fair cart track. From Peinzaik for the third march of 10 miles, there is only a footpath which follows the Peinzaik Chaung for 4 miles, then crosses water-shed to source of the Le-ze Chaung along which it runs to the junction of the Thaing Myaung, where there is a perennial spring and a suitable halting place The fourth march of 10 miles commences with the ascent up the Pandaung range which is crossed at the hill, called Thitpok Taung; ascent 500 feet; hence the path goes along a gradual slope to Kathit Myaung, along which it runs as far as Kywe-de-te, leaving which the Yoma ridge is crossed near a point called Thon-mye-zaing, and thence Aunghla-te is reached without much trouble.

Paungdé to Aunghla-te *viâ* Yoksaing, four marches. First march as above. Second march Ngapaw to Yoksaing; fair cart track; distance 14 miles. Shwele stream frequently crossed. From Yoksaing, which is a small Burman village, there is a good cattle track for the third march practicable for elephants lightly laden. It first skirts the Shwele Chaung to Bam-bwe-gante, 4 miles, whence the path runs along a low ridge for 2 miles up to Wun-din-byit Chaung, and along this stream for 3 miles to where the Yem-hen Chaung joins it. At this halting place there is a good perennial spring. Starting from this point the Pandaung range is crossed on the fourth march, ascent 750 feet, then the Thon-mye-zaing ridge, after which Kywe-de-te is reached. From here the Yoma is crossed to reach Aunghla-te; distance 10 or 12 miles. This path is better than the one *viâ* Peinzaik above described.

With two exceptions, the quality of work executed during the past field season is equal to the previous season's, and the drawing is superior. Owing to the abrupt termination of the field season at the end of April, several gaps have been left in the work, and the portion surveyed has only been partially checked. Unfortunately during the coming field season, it will not be possible to fill up more than two of these gaps as the others lie on the Yoma, which will not be accessible for a season or two, or until the country is quieter. Had it not been for the frequent interruptions already described, there would have been a most satisfactory out-turn, as the party was properly organized, the equipment was sufficient in every respect, and every ordinary contingency had been carefully considered.

Much credit is due to the Assistants and to several of the Sub-surveyors for standing firm at their work in spite of the dangers they were exposed to from dacoits, by whom they were constantly threatened.

Extract from the Narrative Report of LIEUTENANT-COLONEL H. S. HUTCHINSON, S. C., *Deputy Superintendent, in charge, Akyab Cadastral Survey,—Season 1885-86.*

The country known as the Arakan Coast in which Akyab is situated, in many ways closely resembles that of the "Konkan" of Western India. Both lie at an average elevation of a very few feet above the sea-level, both are long narrow strips of country of an average width of 40 or 50 miles, bounded on the east by a chain of mountains and on the west by the sea, and being situated in the same latitudes, their climates also are very much alike. The main difference between them consists in the magnificent wide tidal creeks, which penetrate Arakan far inland, extending even into the hill tracts, and which are navigable for river steamers and large sailing craft for long distances, whilst there are no rivers of importance in the Konkan in any way to compare with them. This is probably the reason why Arakan is so much the damper climate of the two, and its scenery also differs very much on this account. The main rivers of the Akyab District, *viz.*, the "Kaladan" and "Mayu," are some miles wide and maintain a width of 1 to 3 miles for a long distance inland. The Arakan hills, though not dissimilar in outline and formation to the *ghâts* of Western India, are not so bold, and do not form the same peculiar wall or step of 2,000 feet high, whilst they are more rounded and more densely covered with forest. The timber, however, in the Akyab District is not considered valuable, and in consequence there are no forest reserves, though some timber is under especial protection. The Arakanese are a slothful, indolent people, and the labour for cultivation of the country is mainly imported from Chittagong. Indeed, the Chittagonians are, I believe, gradually dispossessing the aborigines of the country; settlers are found all over the Akyab District. The Arakanese are seen most to advantage during their water festival, when they turn out in crowds for boat races, and the country seems alive with excitement. A description of a boat race by Mr. Jarbo, Surveyor, with this party, is given below, as nearly as possible in his own words.

The villages of "Wagun" and "Kyauktaw" lie in a picturesque position, facing and immediately on the left bank of the Kaladan River: they are some 3 miles apart; the portion of the river between them has a high bank and is fringed with lines of jack, marian and other fruit and jungle trees; behind the jungle, and running almost parallel with the river, there are ranges of hills, some of whose peaks reach a height of 3,000 feet, and are for the most part covered by bamboo jungle with here and there a gigantic gurgan tree, many of which are festooned with long sprays of purple orchids, or clothed with graceful ferns. The gaps that occur in the jungle are caused by clearings for cultivation, called *taungya*, and the crops are claimed by the semi-civilized, and more than semi-nude tribe of "Khwaymes" or dog-eaters. Many of the lower spurs are capped with white pagodas, conspicuous in contrast with the green background of the foliage on the higher hills. The pagodas are bell-shaped masses of solid masonry, erected in order to merit *Nekban* (heaven), of no use but ornament. Between the hills and the villages are fields after fields, bearing at the proper season teeming crops of rice, the staple on which alone as yet depends the prosperity of the surrounding country. For the front view our villages have low detached hills with very precipitous sides abutting on to the river whose waters under the shadows of the grey rocks, look but are not unfathomable, for in the water at the mouth of a small rivulet may be seen a herd of buffaloes lying dosing each one with its nose, eyes, and the tips of its horns just visible above the surface of the water, enjoying a mid-day nap in which we cannot afford to join them at present for the day promises to be

a busy one; what with woods and rivers and hills and herds the population of the country have much to be grateful for, and they are as a rule a very contented race; but just at present their thoughts are occupied with other things than the beauties of their surroundings—Who will win at the approaching boat races? and pose as athletes and heroes before the world in general? (and their sweethearts "Thā zan Phyoo" and "Mah Thā loung" in particular).

It is to see the races and to describe the contest of the day between the boats of the two villages above named, that we are now concerned, and to do so with advantage we had better climb the low hills on the opposite bank of the river from which we shall get a bird's eye view of the whole proceedings whilst sitting in the shade of a mutilated torso of an herculean figure of Guadama (unless we sink into an endless reverie and our features, like his, become fixed with the expression of eternal meditation).

Now we have recovered breath after the climb, let us take a good look around. Ah, the first arrivals have reached the wharf, abreast of which is to be placed the winning flag—among them is a podgy figure balanced on a very fat little bay pony, this is the "*Myoôk*" or petty Magistrate and Revenue Collector; he wears the gayest of "*loongyees*" (waist cloth), of the richest and thickest silk, woven with very bright colours into an exceedingly intricate maze of squares, triangles, and zig-zag twisted, turned, and interlaced, called, I believe, the dog-tooth pattern; his iron-grey hair glossy with exuberant oil tied into a compact knot and brought to the very top of his head like the knob of a teapot cover, is encircled with a wisp made of the whitest of white cambric handkerchiefs, and there is no mistaking him for being other than the great man of the country. As he slides off his nag, he is surrounded by a crowd of sleek men whose self-importance will at first only allow them to mumble greetings and hint suggestions, but as arguments wax warmer, dignity is laid aside and then they shout and gesticulate like very schoolboys. At last something has been decided on for a muscular middle-aged man, tucking his *loongyee* high up above his thighs and canting his head on one side to get hold of, and tie up his long back hair which has got loose and hangs to his waist, rushes along the wharf, as if having been worsted in the discussion he is determined to bring it and his life to an end together; but as he nears the edge he evidently thinks better of it, for he turns to his right, and goes deliberately down the steps placed there and draws forth a dug-out (a country skiff, made of one solid bit of wood) from under the wharf, out of which he proceeds to dislodge the water by rocking it to and fro half a dozen times, then taking up the paddle he squats himself on the extreme end of the canoe, dangling one leg in the water, and awaits events; meanwhile others are not idle, for a bamboo raft about 2 feet square has been made, and this a youth now places in the dug-out whose helmsman with a few strokes of his paddle, carries it some 50 or 60 yards away from the wharf and then stops and calls out to know if he has gone far enough; the *Myoôk* decides this knotty question favourably, and the bamboo raft is set afloat at that spot and moored with large stones for anchors, so that it may not be carried away by the tide, and now arises a discussion as to the best way of fixing the winning flag on the raft; for in Arakan the boat, whose crew secures the winning flag and can show it as a token, wins the race, and it is necessary that both should have an equal chance of laying hold of it. One therefore suggests that a hollow bamboo tube be tied horizontally to two posts on the raft with a cane through it which could be easily withdrawn from either end, breadthwise to the river, and that whichever crew succeeded in withdrawing the cane should be declared to have won; this is objected to by others, who say, "No," for perhaps the leading man of the boat which is ahead may miss taking hold of the cane, and that then the leading man of the second boat, and the second and third man of the first boat may seize the cane simultaneously and that then the boats will upset, this will lead to a dispute and doubtless end in a riot as happened in a former year; let there be two flags quite independent of each other." To this there are also objections, but now the old *Myoôk* hits upon a plan which meets the wishes for fair play of all parties. It is this,— a bamboo, about a foot long, is fastened in the centre of the raft in an upright position, and the staff of the flag rests in this as in a socket, the winning boat is to be that one whose crew takes out the flag from the socket. A large rice boat is anchored out in midstream in a line with the wharf and raft, this is for the judges and umpire, besides this, "dug-outs" are stationed at intervals along both sides of what is to be the course to see that each racing boat keeps to its own side of the river, and that there is no foul play. Whilst all this has been going on, sight-seers have been coming in increasing numbers, first in ones and twos, then by the half dozen, till now they form a continuous stream of people dressed in all the colours of the rainbow as well as in others not to be found in it. She who is the happy wearer of a pink *thamine* or petticoat, a delicate, canary scarf over a plum colored velveteen *aengyee* or bodice, and a large bunch of yellow orchids in her hair, is considered quite the star of the day; and he who is dressed in a yellow and black-checked *loongyee* with an elaborate border, a blue cloth jacket, with gold buttons and a light pink head-kerchief or *gaung boung* with a magnolia blossom behind one of his ears, is looked upon as the cream of gentility. As the boat races are to be followed at night by a *zat pway* or dramatic performance by male and female artists of famed excellence and beauty, whole families may be seen bringing with them the wherewithal to make themselves happy and comfortable for two or three days and nights, should the entertainment last so long; this consists of loads of cooking utensils, bundles of mats, and trays upon trays of sweets and other edibles of sorts, not the least important being bowls of roasted beetles, and grasshoppers, fried snakes, pickled tea leaves, and the inevitable *ngapi* or fish-paste, fra-

grant to the nostrils and delicious to the palate of the true Arakanese. There is an old grandmother with the mats, the mother with a tray of cigars and a baby—without this latter appendage a Burman woman would be ashamed to appear in public; the father heads the procession with the pet of the family on his shoulder—a boy of four or five years—decked out as an exact miniature of himself, the rear is brought up by a grown-up son, preceded by his sisters, his cousins and his aunts, chattering, laughing with, and at times teasing each other, their whole manners and actions indicative of the spirit and delight with which they intend to enter into the business of entertaining and being entertained. It is now 3 o'clock and time that the racing boats should appear, for it is very nearly high tide. What is that coming up stream? It looks like a procession of canoes, for surely it is not one boat. Yes, it is, now that it is closer we see it is but one, and that by its flag, an English blue ensign with the design of a white pagoda worked on the blue ground, it is the racing boat of Kyauktaw. As regards length, it is an enormous boat, being fully 120 feet long, but barely 3 broad; it is in fact nothing more than a very long dug-out made of one tree, and so shallow and light is it that it looks a mere straw on the water. In the centre is a platform flush with the top of its side, on this is slung a large gong, around which are gathered some half dozen musical performers, whose notes are expected to instil and keep alive the spirit of emulation in the crew of eighty rowers, or rather paddlemen; these are seated two abreast, twenty pairs being on each side of the orchestra. Each rower is armed with a paddle made of a dark-coloured wood, nicely polished, and wears a pink head-dress. The boat is steered by a very long flat-bladed oar, fixed over the stern of the boat, and projecting some distance beyond it; with this powerful lever the boat can be steered to a nicety and turned completely round in its own length.

Here comes a second similar boat bearing the Wagun flag, an English red ensign with a black *Beloo* or demon embroidered on the red ground, lilac coloured head-kerchiefs being the distinguishing head-dress of its rowers. These are the great rivals, though there are eight other racing boats now present they are smaller editions of the above, differing from them in the number of paddles, the devices on the flags, and in the colour of the uniforms. The crowds lining the river banks begin to evince signs of impatience, the friends and sympathizers of one boat constantly call out to their crew to know when the start is to be made, and remind them that they have to pull for the honor of their village, and the smiles of its girls, whilst those of the other chaff and criticise their appearance and prospects with the ladies, very much after the style of an English mob on a like occasion.

At last the race is to come off, the boats are brought up parallel to each other near midstream, and they are to start by mutual consent. The coxswain in each boat now chants what sounds like an invocation, "*Maungdoo Maungdoo-yee yee,*" which is repeated by the crew who are holding their paddles upright poised in the water; he then intones "*Ngado Hlay-go-pyin ya lay-gyee,*" to this his crew taking up his note respond with "*Nindoo Souk Kyoo Nga ya lay gyee*" followed by—"*Hlaytuga, Hlaybaw, Hlaybaw thait Ka,*" from the coxswain, answered by the rowers with "*Taung Loong Gyawdthey, Taung Loong Gyaw.*" The gong is now struck with a pause of slow time at first between each stroke; this serves to mark the time and get the rowers into the correct swing, as it is accompanied by each of the crew making a sweep of his paddle, passing it in a circle above his head, and down into the water, shouting his war cry of "*Hayla Heela,*" "*Hayla Heela*" with each dip of it.

The strokes on the gong become more rapid, the paddles keeping time with it. Suddenly the helmsman of one boat throws up his arm and gives a loud shout, and both boats literally dart forward like birds. The beats of the gong and the *hayla heela* of the rowers are repeated now as fast as hand can strike and tongue articulate, the whole eighty paddles of each boat keeping exact time in dipping, with the precision of a machine: so true are the movements that it is almost incredible that the motive power furnished by no less than eighty pairs of arms, and as many distinct wills can conduce to a result which rivals in accuracy the motions of the nicest mechanism prompted by but one motive engine. Soon after the start has been made the band strikes up, and some of them begin to dance on the centre platform, some imitate the flying of birds by flapping their arms, others the swimming of fishes balancing themselves the while so as not to interfere with the trim of the boat, but keeping time to the music. At the prow one performs a *pas seul*, the movements of his arms and hands representing capitally the beating of a bird's wings through the air. The clean dip of the paddles, the rapid but smooth gliding of the boat, and the graceful actions of the dancers may well be called the poetry of motion. As the winning flag is neared, the rallying cry becomes a succession of shrieks. The Wagun canoe leads by a foot or two, but the Kyauktaw coxswain gives a shout of encouragement to his men, and makes two rapid sweeps with the oar which serves as a rudder, this, acting like the screw of a steamer, brings both boats level. They are now within six inches of the end of the flag-platform, and it seems as if they will run down it and each other. There !!!, the dancer on the prow of the Kyauktaw boat has made a grab at, and succeeds in grasping the coveted flag; this he waves in triumph over his head, and a perfect roar of applause arises from the spectators on the banks; all discipline on board is now at an end, for the whole crew are capering about at the risk of upsetting their craft, dancing, shouting, singing, kicking up their legs behind and before, and slapping themselves and each other in excess of joy; paddles, long hair, and handkerchiefs flying about in all directions, testify to the delight of their owners at having, after a very severe

struggle, won the race; so equal a contest was it, that had the man at the prow of the Wagun boat had an arm and fingers but two inches longer the result would probably have been different, for he made his grab for the flag simultaneously with that of the Kyauktaw man: in fact to English ideas the race ended in a dead heat.

Miss Thā-zan Phyoo, or "White orchid," is all smiles and tears as she offers her swain from the Kyauktaw boat the choice of her tray of cigars; this is by no means refused, nor is the further favour of lighting it for him, which she proceeds to do after giving it a caressing lick with her tongue which is doubtless appreciated. Beautiful "Mah Tha loung" of Wagun fame affects an indifference, we dare say she does not feel, unless indeed having no partiality for any of the crew she can afford to keep her sympathies for another occasion.

And now the chief event of the day is passed and the greater portion of the crowd have already left the river bank and are engaged in regaling with divers dainties the recent competitors who have each been presented with a gaudy handkerchief by the *Myoôk*; so we will descend the hill and leave the holiday makers to complete their day's sport without our presence, hoping it may end as peacefully as it has begun.

Extract from the Narrative Report of LIEUTENANT-COLONEL S. H. COWAN, *Deputy Superintendent, in charge Basti Cadastral Survey,—Season 1885-86.*

As the Benares records are now all complete, and no further charges against that district will appear in the accounts of the party, a final statement is here given of the cost of the survey and of the *pargana* areas, &c.:—

District Benares.

Nature of Survey.	Scale.	No. of villages.	No. of fields.	Square miles.	Cost.	Remarks.
	Inch.				₹ a. p.	
Field Survey	16	2,272	951,919	988·48	1,63,331 14 7	Includes the amount of ₹4,365 expended on marking theodolite stations.
City Survey	32	44	40,899	10·98	9,772 0 0	
TOTAL		2,316	992,818	999·46	1,73,103 14 7	

The following Comparative Statement shows the Benares rates and the rates for two adjoining Districts.

	Ghazipur.	Ballia.	Benares, including City.	Benares District (not City.)	Benares City alone.
	₹ a. p.	₹ a. p.	₹ a. p.	₹ a. p.	₹ a. p.
Rate per square mile	167 2 6	157 5 9	172 6 9	165 4 4	890 0 0
„ Village	66 1 9	72 4 10	75 0 4	72 8 1	
„ Acre	0 4 2	0 3 11	0 4 4	0 4 2	...
„ 100 Fields	12 4 9	12 5 7	17 7 11	17 4 9	...
Average size of Village	253	294	278	280	...
„ Field	·48	·50	·65	·67	...

In these amounts and areas, the Pargana Kaswar Raja is included (305 villages, 211 sheets, 125,661 fields, 118·25 square miles); for the survey, records and maps of which, the Maharaja has paid ₹22,000. Of this sum ₹3,200 is the cost of printing cadastral maps, being at the rate of about ₹15 per sheet, leaving ₹18,800 for survey and records. The cost may be estimated in three different ways, *viz.*:—

	₹ a. p.	₹ a. p.
118·25 square miles	@ 165-4-4 per square mile	= 19,543 4 5
305 villages	@ 72-8-1 per village	= 22,118 0 0
125,661 fields	@ 17-4-9 per 100 fields	= 21,735 6 9

so that whichever calculation is adopted, the Maharaja is a gainer.

The Maharaja's Settlement Officer (styled Additional Principal Revenue Officer), Munshi Krishna Chandra, M.A., has favoured me with the following extract from the Report of the Deputy Superintendent, Family Domains, Maharaja Benares, on the Gangapur Settlement.:—

"The total cost of survey and printing the maps, as paid by the Maharaja to Government, amounts to ₹22,000. This, on a corrected area of 118·7 square miles, amounts to about ₹186 per square mile. This is considerably in excess of the estimate, which was for about ₹140. The excess is probably owing to the minute sub-division of the cultivated area. The cost of attestation, settlement of disputes, and fairing the papers, irrespective of the Maharaja's personal expenditure in the employment of agents to look after his interests, amounted to a further sum of ₹10,740 or about ₹91 per square mile."

Particulars of District by Parganas.

Pargana.	Villages.	Sheets.	Fields.	Acres.	Square miles.	Average size of Villages.	Average size of Fields.
						Acres.	Acre.
Narwan	201	162	79,875	67340·50	105·22	335	0·84
Barhwal	131	95	62,994	41282·01	64·50	315	0·65
Majhwar	185	140	64,973	48534·05	75·83	262	0·75
Dhus	84	71	37,981	29098·08	45·47	346	0·77
Mahuari	78	67	25,614	22657·20	35·40	290	0·88
Mawai	51	38	13,516	12234·82	19·12	240	0·90
Raihupur	80	60	19,238	19638·33	30·68	245	1·02
Barah	94	91	28,176	31577·08	49·34	336	1·12
Athgaon	164	89	42,910	22996·63	35·93	140	0·54
Kolasla	147	136	126,800	55926·32	87·38	380	0·44
Pandraha	103	85	64,347	30833·82	48·18	299	0·48
Sultanipur	31	22	15,653	7626·83	11·92	246	0·49
Katehir	215	193	104,892	66179·17	103·40	308	0·63
Jalhupur	62	81	24,920	28906·18	45·17	466	1·12
Shiupoor	111	71	33,574	21049·08	32·89	190	0·63
Dehat Amanat	142	141	76,847	36268·46	56·67	255	0·47
Kaswar Sirkari	132	81	44,847	28233·38	44·11	214	0·63
Kaswar Raja	305	211	125,661	75680·00	118·25	248	0·60
Total	2,316	1,834	992,818	646061·94	1009·46	279	0·65

The *bigha* in Benares is equal to 3,136 square yards nearly, 1 acre being equal to 1 *bigha* 10 *biswas* 17·3445 *dhurs*.

Extract from the Narrative Report of MAJOR J. E. SANDEMAN, S.C., *Deputy Superintendent, in charge Gorakhpur Cadastral Survey,—Season 1885-86.*

The Hata Tahsil contains the following *parganas;* the names of the *tappas* within the latter, their area and the number of *mouzahs* are also given :—

Number of Mouzahs.	Names of Tappas.	Parganas.	Area.
	Agaya	Haveli	4906·98
	Bandwar	Hata	14072·14
	Bharsand		19685·72
	Dedupar		17653·85
	Padkhori		9192·40
	Parwarpar		36159·74
Totals . 229			101670·89
	Bachauli	Sháhjahánpur	13106·31
	Bhainsadabar		8085·26
	Bhitni		5101·70
	Chak Daia		9412 25
	Majhana		1960·64
	Nagwan		19503·80
	Padiapar		4683·52
	Patnan		11478·36
	Tarkulwa		14240·71
Totals . 258			87572·55
	Bakhra	Silhat	3577·90
	Banchara		15089·25
	Barnai		3223·07
	Binack		3160·25
	Chariaon		6972·52
	Dhatura		12192·46
	Donth		2143·72
	Gaura		1910·05
	Idrakpur		1664·16
	Indupur		15002·05
	Kataura		4394·80
	Madanpur		6522·13
	Nagwa Tikar		72543·19
	Narainpur Chiuraba		6762·02
	Paharpur		2207·26
	Singhpur		13163·38
	Sirjam		6116·19
Totals . 507			176644·40
GRAND TOTAL . 994			365887·84

An exception to the usual dead level of the country is a sand ridge, about 30 feet high, which runs south through Haveli Pargana and is continued along the border of Silhat and Sháhjahánpur and which crops up at intervals in both *parganas*.

The proprietary tenures of the *mousahs* are as follows:—

	Zamíndari Wahíd.	Bilijmel Zamíndari.	Pattídari na-mukammal.	Pattídari mukammal.	Total.
Haveli	44	114	64	7	229
Sháhjahánpur	36	72	142	8	258
Silhat	55	150	291	11	507

In this *tahsil*, as in all others in the district, the shares of proprietors when they are numerous, as is often the case in coparcenary villages, are recorded in the following divisions of an anna:—

20 phens = 1 rehn.	3 kants = 1 kaurie.
20 rehns = 1 dant	4 kauries = 1 ganda.
3 dants = 1 kant.	20 gandas = 1 anna.

The sizes of the *pargana bighas* are as follows:—

	Square yards.		Square yards.
Silhat	3,161	Haveli	3,164
Sháhjahánpur	3,600		

The total amount of cultivation and of irrigated and dry cultivation in the *tahsil* is as follows, in acres —

	Irrigated.		Total.		Total of cultivation.
	From wells.	From other sources.	Wet.	Dry.	
	Acres.	Acres.	Acres.	Acres.	Acres.
Haveli	6,322	24,938	31,260	41,792	73,052
Sháhjahánpur	11,623	16,335	27,958	40,490	68,448
Silhat	38,062	45,089	83,151	54,944	138,095
				Total	279,595

The areas of land cultivated by proprietors and tenants in the various *parganas* of this *tahsil* are as follows:—

	Sir and Khud-kasht.	Tenant's land.
	Acres.	Acres.
Haveli	6,633	65,335
Sháhjahánpur	12,150	55,469
Silhat	36,003	100,024

The numbers of and the areas cultivated by occupancy tenants and tenants-at-will are contrasted below:—

	Occupancy tenants.		Tenants-at-will.	
	No.	Acres.	No.	Acres.
Haveli	12,793	40,001	17,706	25,334
Sháhjáhanpur	20,583	40,892	15,957	14,576
Silhat	31,740	63,668	33,096	36,355

The number of rent-free-tenants and areas cultivated by them—

	No.	Acres.
Haveli	391	887
Sháhjahánpur	968	1,683
Silhat	769	1,847

The average sizes of the two kinds of holdings in this *tahsil* are—

	Acres.
Occupancy tenants	2·22
Tenants-at-will	1·14

The areas of culturable and barren land in the three *parganas* are as follows :—

Culturable.

	Fallow.	Groves.	Grass.	Bush.	Total.
	Acres.	Acres.	Acres.	Acres.	Acres
Silhat	18,494	4,018	1,239	839	24,590
Sháhjahánpur	9,994	1,566	474	166	12,200
Haveli	16,802	2,030	1,171	73	20,076

Barren.

	Sites.	Water.	Otherwise barren.	Total.
	Acres.	Acres.	Acres.	Acres.
Silhat	3,265	7,655	3,039	13,959
Sháhjáhanpur	1,948	3,061	1,916	6,925
Haveli	1,831	4,149	2,562	8,542

The cultivated areas under the various soils are as follows :—

	Sháhjahánpur.	Haveli.	Silhat.
	Acres.	Acres.	Acres.
Dorus (loam)	57,606	52,919	66,818
Matyar (clay)	9,839	19,153	14,394
Balua (sand)	1,004	980	7,088
Bhat (a cretaceous soil)	...	...	312
Kachhar (lands inundated in the rains)	...	...	407

The conventional tracts, as divided for assessment purposes, and to which the rates of rent often conform, have the following areas :—

	Haveli.	Sháhjahánpur.	Silhat.
	Acres.	Acres.	Acres.
Goend (Home-lands)	7,023	8,642	24,106
Manjhar (middle tracts)	15,139	17,303	53,679
Palo (out-lying)	50,891	42,504	60,311

The following is an abstract of the agricultural statistics, which were collected, by *parganas* :—

	Wells.			Ploughs.							
	Masonry.	Earthen.	Total.	2 bullocks.	4 bullocks.	Total.	Plough cattle.	Other cattle.	Sheep and goats.	Horses.	Sites.
Sháhjahánpur	1,546	900	2,446	9,608	100	9,708	21,792	34,853	12,988	216	594
Haveli	1,130	790	1,920	10,565	26	10,591	23,565	44,438	10,053	120	558
Silhat	3,658	2,658	6,316	21,952	89	22,042	45,695	60,050	16,637	711	19,33

There are 5·48 sites of villages in each square mile.

The following are the areas in the three *parganas* under some of the principal crops in the autumn and spring harvests—

KHARIF.

KHARIF.	Haveli.	Shâhjahânpur.	Silhat.	TOTAL.
	Acres.	Acres.	Acres.	
Rice (Aghani and Bhadain)	45,177	24,524	37,371	
Kodo	838	2,822	10,723	
Arhar, with jowar and bajra	287	6,000	17,030	
Arhar	3,045	140	821	
Makai	94	1,648	568	
Jowar	258	497	1,911	
Garden food crops	70	152	60	
Other food crops	890	1,271	4,463	
Total food crops of the Kharif harvest	50,659	37,454	72,947	161,060
Sugarcane	5,272	6,911	5,080	
Cotton	13	88	15	
Indigo	15	13	275	
Garden non-food crops	...	2	13	
Other non-food crops	620	663	419	
Land prepared for sugarcane	4,293	5,640	2,483	
Total non-food crops in the Kharif harvest	10,213	13,317	8,285	31,815
RABI.				
Wheat	8,826	5,666	11,850	
Barley	1,001	2,979	29,565	
Gojai, wheat and barley	3,448	10,446	15,400	
Bijra, wheat or barley and gram	152	2,112	1,313	
Gram	3,740	...	6,790	
Kiran	11,563	9,229	19,917	
Potatoes	25	42	54	
Masur	1,095	746	205	
Garden food crops	50	108	157	
Other food crops	11	30	653	
Total food crops in the Rabi harvest	29,911	31,358	85,910	147,179
Opium	7	325	1,416	
Tobacco	27	13	50	
Tisi	9,698	4,802	} 9,749	
Sarson	...	3		
Garden non-food crops	...	...	44	
Other non-food crops	1	17	26	
Total non-food crops in Rabi	9,733	5,160	11,285	26,178

The double-cropped areas are,—in Shâhjahânpur 18,842, in Haveli 27,465, and in Silhat 40,336 acres.

The numbers of cultivators of each caste and the areas cultivated by them in the three *parganas* are given below:—

	Haveli.		Shâhjahânpur.		Silhat.	
	No.	Acres.	No.	Acres.	No.	Acres.
Mahomedans	896	2,768	2,678	5,735	1,598	3,406
Brahmans	2,212	6,683	2,935	7,826	7,193	21,963
Rajputs, Thakurs or Chatris	840	3,742	1,988	6,913	4,818	18,392
Banyas	370	1,045	705	1,257	963	1,851
Kayats	291	1,388	498	1,273	491	2,507
Chamar or Dusadh	2,792	5,252	2,153	3,262	3,570	6,741
Ahir	1,840	4,350	3,187	6,353	6,581	15,597
Koeri	492	1,301	1,749	3,854	1,547	3,753
Kurmi	6,094	22,723	3,524	10,094	5,392	18,932
Kahar, Malla or Gondh	537	1,027	660	1,094	4,385	9,847
Dhobi	434	885	506	766	459	717
Teli	897	2,387	963	1,795	1,293	2,694
Julaha	535	1,089	945	1,429	943	1,685
Nanera	394	943	598	1,083	1,728	3,821
Barai	202	514	312	586	396	850
Kalwar	178	493	518	921	358	813
Nai	406	739	496	703	606	873
Other castes	6,355	15,725	6,897	13,504	10,068	22,653
TOTAL	25,765	73,054	31,312	68,448	52,389	137,095

Sugar boiling is extensively practised in all three *parganas* of this *tahsil*. The areas under sugar cultivation, as is apparent from the crop statement given above, are very large, and there are sugar-mills (*Kolhu*) in almost every village. The juice is extracted and boiled and the *gur* is taken to the nearest factory. The factories generally advance money to the cultivators. There are sugar factories at many of the large villages.

Ancient monuments are scattered over the *tahsil*, notably at Rudarpur. Some are the remains of Budhist convents and relic temples. At Rudarpur are the remains of a quadrangle, about 350 yards square, enclosed by a mound of brick which rises 40 feet above the surrounding country, which is strewn with bricks.

Extract from the Narrative Report of MR. A. D'SOUZA, *Officiating Deputy Superintendent, in charge Sambalpur Traverse Survey,—Season 1885-86.*

Sambalpur is the most eastern district of the Chhattisgarh Division of the Central Provinces. The Khálsa portion of the district is divided into two *tahsils* or sub-collectorates by the River Mahánadi, the one on the right bank being called Bargarh, and that on the left the Sambalpur Tahsil. These positions are also locally known as the Dakhintir and Utartir from their positions with respect to the river; that which is south of the river is called Dakhintir and that to the north the Utartir.

The portion surveyed in the Utartir or Sambalpur Tahsil embraces the tract of country between latitude 21° 5′ and 21° 35′ and from the River Mahánadi to the eastern boundary of the district. The country surrounding the town of Sambalpur and that along the bank of the river is highly cultivated. To the east and south where there are mostly forest reserves and hilly tracts, the country is undulating, with some clumps of hills more or less rugged, and occasionally an isolated hill to break the monotony of the undulation. The most notable among the mass of hills to the south is the Bodapali range which attains the height of 2,331 feet above sea level. The country is so densely covered with forest trees and under-growth, combined with bamboos, that it was a source of great difficulty to the surveyor who surveyed the portion last season. The country besides is notoriously unhealthy, poorly inhabited, and the villages are very few and far between; those met with, are composed of three or four huts only, and as the field season advances, there is a great scarcity of water and the few inhabitants of these parts leave the place for the cultivated plains near the larger streams. It is difficult therefore to procure coolies and guides to point out the boundaries of the forest reserves and villages. The tract abounds in large game, *viz.*, elephants, bison, tiger, panthers, deer, &c.

The portion surveyed in the Bargarh Tahsil consists of 550 square miles of level open country, similar to that surveyed last year, and the Bara Pahar—a range of hills situated at a conspicuous bend of the Mahánadi River which flows on three sides of it. The highest point of this range is Dabrugarh, which attains the height of 2,267 feet above sea level. This hilly tract is densely wooded and presents most formidable obstacles to the traverse surveyor who has to follow up the village boundaries which run through them.

Sambalpur is the only town of the district. It is situated on the left bank of the River Mahánadi $\frac{\text{Latitude } 21^{\circ}\ 28'\ 15''}{\text{Longitude } 84^{\circ}\ 0'\ 50''}$. It is about a couple of miles in length, having about 2,500 houses and a population of 13,939 inhabitants. There is nothing very remarkable in it but a few tottering bastions of an old fort and a dilapidated palace which still remains to speak of its past history, when it was in the possession of a Garjat Chief. It was annexed by the Government of India in 1849 on the demise of the Raja who left no male issue to succeed him on the throne. The river here is about a mile broad and is sometimes full during the monsoon from bank to bank, but after the rains, the channel of the river is about 50 to 60 yards in breadth and in some places of considerable depth. It is crossed by a ferry. The bed of the river is covered with boulders of rocks, by the sides of which grows the *jhow* tree forming little green islets here and there, which adds much to the beauty of the scenery.

Bargarh, the head-quarters of the *tahsil* $\frac{\text{Latitude } 21^{\circ}\ 19'\ 50''}{\text{Longitude } 83^{\circ}\ 39'\ 33''}$ is a small town on the road to Raipur. It has a subordinate Magistrate's *kacheri*, police station, post office and school.

The Mahánadi is the only large river in the whole district, it takes its rise in the Bastar District and flowing in a northerly direction, it reaches the Bilaspur boundary where it receives the waters of its great affluent, the Seonáth, and taking an easterly course, enters the Sambalpur District and passes the town of Sambalpur. It then flows south and south-easterly to Cuttack and then branching out into its numerous estuaries, flows towards the coast and empties itself into the sea. It is navigable by boats as far as Seorinárayan, for the greater portion of the year, when a very large quantity of grain and other produce of the country are conveyed to Cuttack for shipment to other ports.

Gold dust has been found in the Mahánadi and the Ib Rivers, and diamonds in an island called Hira Kund, which is about 6 miles north of the town of Sambalpur.

Extract from the Narrative Report of CAPTAIN R. A. WAHAB, R.E., *Officiating Deputy Superintendent, in charge Himalaya Party,—Season 1885-86.*

The country triangulated lies in the Sutlej Valley, between the outer Himalaya range which forms the Sutlej-Beas water-shed and the high range, which running eastwards from Nárkanda, forms the southern water-shed of the Sutlej. Several G. T. S.

secondary stations and points fall within this area, but few of them could be identified. South of the Sutlej, Hatúgarh h.s. and Tumru h.s. were satisfactorily identified, and form the basis of the triangulation; north of the Sutlej only Núnúkanda h.s., and Ghamain h.s., out of six or seven stations visited, were found.

The ranges which enclose the part of the Sutlej valley under survey, average from 9,000 to 11,000 feet above sea-level; from them steep spurs, divided by deep valleys, run out to the river, from the level of which (about 2,500 feet) up to an average height of perhaps 6,000 feet the hill sides are bare, and wherever the slope admits, dotted with villages and patches of cultivation. Above that height they are generally thickly clad with forest, chiefly *Kail*, or blue pine (*Pinus excelsa*) and *Rai* or Himalayan spruce (*Abies Pindrow*): Deodar is also found in places near the lower limit of the forest tract and on the warmer and drier slopes; at a still lower elevation patches of *Chir* (*Pinus longifolia*) are met with.

The only places of any importance in the country under survey are Kotgarh, in the British State of the same name, and Rampur, the residence of the Raja of Bashahr, and a well-known market for shawls, *puttoo* and all kinds of woollen manufactures. At Kotgarh there is a Mission church and several European residents.

The Hindustan-Tibet road passes through Kotgarh and Rámpur, from each of which places roads run north into Kullu. From Kotgarh a road leads by Suket and Mandi into Kangra.

The party reached their ground rather later in the season than was desirable, the operations in Kangra having occupied them until late in April, and as no preliminary work, such as selecting stations or erecting marks had been done beforehand, the work of observing was not commenced till late in May when hazy weather set in and greatly delayed work. The heat in the low, shut-in valleys was very great and the labor of climbing the steep, bare hills of the Sutlej valley under a June sun was very trying. The health of the party was, however, on the whole good; one death from pneumonia among the Hindustani *klassies*, and several cases of fever occurred. Work was closed on the 4th July when the Rains had fairly set in, and the party reached Simla and commenced recess work by the 15th idem.

During the recess the computations of the triangulation have been taken in hand. That of Kotgarh, the detail survey of which is to be shortly commenced, is completed, and copies of the trigonometrical data required by the Forest Survey in and around Kotgarh have been made for that department. The remainder of the computations are well advanced, and a large area will be ready for detail survey at the end of the recess.

Extract from the Narrative Report of MAJOR J. HILL, R.E., *Deputy Superintendent, in charge Tidal and Levelling Operations,—Season 1885-86.*

The working of each observatory, commencing with Aden and Kurrachee and following the order of the stations round the coast, will now be briefly described.

Aden.—The self-registering tide-gauge has worked very satisfactorily throughout the year; there have been only six unimportant interruptions in the working of this instrument, occasioned as follows. On the 24th October 1885 the float band was removed to clear out the cylinder and pipe, the accumulation of mud in which had been causing a slight discrepancy between the reading of the pencil and the graduated staff; on the 4th December the driving clock stopped for three hours; on the 20th February the pencil broke, causing a break of three hours; on the 8th April the wire at the clock end, to which the counterpoise weight of the pencil is attached, broke at 8 P. M., but it was repaired at 7-30 the following morning, when the clerk in charge of the observatory went to his duties; on the 2nd July the wire at the clock end broke again, and 13 hours' registration was lost; and finally on the 6th August the clock stopped for six hours.

The self-registering anemometer had only three interruptions in its registration caused by the stoppage of the driving clock, *viz.*, on the 20th October for 3 hours, on the 16th November for 6 hours, and on the 17th November for 23 hours.

The self-registering aneroid by Adie has worked without a single failure throughout the year.

The self-registering aneroid by Légé is in good order and is kept working, although its diagram is not renewed, while the instrument is kept only in reserve.

Accompanied by Sub-surveyor Dhondu Venayak and the watch-maker of the party, I inspected the observatory between the 18th and 24th August 1886. The cylinder was cleaned out, and it was discovered that the rose and bent pipe had disappeared and could not be found; it was also plain that for some time there had been a direct flow of water into the cylinder. The well was found to be quite clean, and as the curves on the diagrams had been satisfactory, there was no necessity to attach a new rose, and the direct communication was allowed to remain. The instruments had not been cleaned since the inspection made in November 1883, or nearly three years ago, and though after so long an interval they were found to want cleaning badly, their performances had remained very good. They were thoroughly cleaned and oiled, and a new float band was substituted for the old one which was nearly worn out.

The several instruments were left in thorough good condition.

Captain Thyne, the Port Officer, continues his kind co-operation, and has rendered valuable assistance to the operations by his supervision of the clerk in charge.

Kurrachee.—The self-registering tide-gauge registrations at this port are very good; there were five interruptions of from 1 to 5 hours' duration, each caused by the communication holes in the cylinder getting choked with shell-fish; there were also three more from the imperfect working of the driving clock; one of these was on the 5th February when the clock was removed to be cleaned, it was however replaced on the following day and thereby only 19 hours' values were not registered, and on the other two occasions the clock stopped for 3 hours; in addition to these interruptions there were three failures in the working of the pencil from accidents to the cord attached to the counterpoise weight, by which a few hours' work in each case was lost. The whole of the interruptions being only for a few hours each, the breaks in the curves were easily filled up.

The self-registering anemometer had only two breaks in its registration—one on the 20th July last of thirteen hours, and another of six days between the 13th and 19th August, during which time the driving clock was being repaired and cleaned.

The self-registering aneroid had only one break in its registration of four days when the clock was removed to be cleaned on the 12th November and not re-started till the 16th of the same month.

Acknowledgments are again due to Mr. Price, the Port Engineer, for his continued interest and co-operation in the work, and for the prompitude with which he has caused all necessary repairs to be made, and so saved the registration from any serious interruptions.

Bhávnagar.—A description of this observatory having been given last year and incorporated in the General Report for 1884-85 (p. liv), it need not be repeated here.

The instruments for use at this port were erected in December last in the observatory house, which had been prepared for their reception during the previous month, and the work may be said to have commenced from the 1st January 1886, since which time the self-registering tide-gauge has worked satisfactorily; on the 19th and 20th February the tidal curves were not registered owing to an accident to the pipe leading into the cylinder; on the 27th and 28th February the instrument stopped work for twenty-one and six hours respectively, owing to a piece of cloth choking up the pipe; and on the 23rd March and 24th June the clock stopped for about twelve hours. In addition to the above there were several minor interruptions of a few hours each, caused by the flushing out of the cylinder which requires cleaning very frequently.

The self-registering anemometer and aneroid have worked very well since they were put up, there having been only two failures in the registration of each of these instruments caused by the stoppage of the driving clock for a few hours on each occasion.

All preliminary arrangements having been very satisfactorily made by Sub-surveyor Dhondu Venayak, the observatory was inspected and started by Mr. Belcham in December, when the several instruments were left in excellent working order. All the instruments belong to His Highness the Thakore Sahib of Bhávnagar. In addition to their cost the cost of construction and maintenance of the observatory, the salary of the clerk and all expenses connected with the tidal registrations at Bhávnagar are generously borne by His Highness. Mr. Proctor Sims, the State Engineer, devised all the special arrangements necessary for the erection of the observatory, the difficulties of which were considerable owing to the great rise and fall of the tide at Bhávnagar. Warm thanks are due to him for the great interest he has been taking in the work, and for the skill with which he has, after several years of experimental work, overcome all difficulties connected with the establishment of the observatory.

Bombay (Apollo Bandar).—The registration throughout the year by the self-registering tide-gauge at the Apollo Bandar is perfect, not a single break having occurred. There is no anemometer or barometer at this observatory.

The observatory was inspected in December last by Mr. Belcham, who reported that the float band was rusty and nearly worn out, and that it should be changed. This will be done at an early date. The clerk continues to perform his duties most satisfactorily. Thanks are due to Mr. Ormiston for his continued interest in the work.

Mormugáo.—The registration of the tidal curves at this port by the self-registering tide-gauge has been perfect, not a single failure having taken place throughout the year.

A tidal disturbance at this place is noticeable on the diagram of the 23rd May last, on which date at 9-15 P.M., the water, after having risen 6 inches above low water which occurred about half an hour previously, suddenly began to fall and in half an hour had fallen 18 inches or about a foot lower than the point at which it stood at low water. The tide then turned and rose with equal rapidity to the height from which the abnormal fall began, from which point the rise continued without any further irregularity. This disturbance seems to have been merely local. The wind at the time was very variable, as between 8 P.M. and 11 P.M. it veered almost completely round the compass, *viz.*, from north-east through east and south right round to north with a velocity of 20 miles an hour.

Up to the date of the last General Report the self-registering anemometer was working well. About the middle of March last the clerk was sick for a few days, and the diagram consequently could not be changed From that time the working of the instrument has been unsatisfactory. On the 23rd March, the cord attached to the driving weight of the clock broke, but was repaired by Mr. Belcham on the 3rd April. The clock stopped

again on the 9th June and was re-started on the following day, but on the 28th July it failed again and since that date it has not been working, for it cannot be re-started until the watch-maker can be sent to repair it.

The old pattern self-registering aneroid by Adie, modified by Légé, continued to work very satisfactorily, there being only two interruptions of 14 hours each, until the 7th May, when the gold wire attached to the pencil broke. Its readings, however, are registered daily at 7 and 10 A.M. and 4 and 6 P.M., and this will be continued until the watch-maker repairs the breakage.

The new pattern self-registering aneroid by Légé and Co., which was set up as a reserve instrument last year, worked very well for a few months, but when the observatory was inspected in April last, Mr. Good, the Executive Engineer of the Harbour Works, brought to Mr. Belcham's notice that the instrument had stopped working in September. Mr. Belcham then carefully examined and re-started it, but it soon stopped again and is not now working.

The observatory was inspected in the beginning of April by Mr. Belcham, but the several instruments and clocks could not then be cleaned, as the watch-maker attached to the party was away on duty at other tidal observatories. He will accompany the inspecting officer at the next inspection, which will be made as soon as possible after the beginning of the coming field season.

Acknowledgments are again due to Mr. Good for his continued assistance.

Cochin.—This new observatory, at which tidal observations were started for the first time on the 25th January 1886, is situated in the storeyard of the Marine Department, on the eastern side of the Cochin river. The observatory house and float cylinder were sent from Beypore when observations were discontinued there in March 1885. The house however was very dilapidated, and a great part of it had to be removed, and all the piles on which it rests are new. Communication with the water is effected by means of a pipe, 36 feet long and 3 inches in diameter, terminating in a rose. The pipe leaves the cylinder 2 feet above its bottom and enters the water 2 feet below lowest low water.

The instruments also are those which had been at work at Beypore and had been sent to Messrs. Légé and Co. in April 1885 for modification. They were received in Bombay and trans-shipped to Cochin in December 1885.

The self-registering tide-gauge worked, with a few interruptions of from two to seven hours' duration, from the 25th of January to the 8th July; but on the 9th July the clock stopped and all attempts to make it work proved fruitless: on receipt of a telegram from the Port Officer, the watch-maker of this party was sent down to repair the clock. He put it into order on the 22nd of the same month, from which time the instrument has been working satisfactorily, and in two instances only the error in the clock has exceeded three minutes.

The self-registering anemometer has only stopped twice since being set up; on the 20th March for seventeen hours and on the 24th idem for three hours. The watch-maker cleaned and repaired the clock on the 24th July, after attending to the tide-gauge clock, since which time the registration has been continuous.

The clock of the self-registering aneroid stopped for six hours on the 9th February, after which it was found to be working badly, but it was cleaned by the clerk in charge of the observatory on the 27th February, and since then its registration has been continuous.

The erection of this observatory was carried out under the immediate superintendence of Captain J. E. Winckler, the Port Officer, whose experience of our tidal observations at Vizagapatam, while he was Port Officer there, was a great advantage in the present instance, and whose kind co-operation deserves warm acknowledgment. The instruments were put up and the work started by Sub-surveyor Dhondu Venayak, and all the details of a full inspection were carried out by him before leaving the port, but the inspecting officer's visit has yet to be made. This will be done at an early date.

Colombo.—The registration of the tidal curves has been continued without a single failure in the working of the clock, but the curves between the 1st November and 5th December were untrustworthy, as Lieutenant Longe who inspected the observatory noticed a difference of over a foot between the readings of the level of the water inside and outside of the float cylinder, from which it was apparent that the pipe admitting water into the cylinder was blocked: the pipe was immediately detached, and it was found that, with three exceptions, the whole of the perforations in the rose at the end of the pipe were completely blocked with a rusty deposit. The blockage must have been gradual, and consequently the level of the water inside and outside the cylinder must have been gradually reaching the startling difference of a foot, but notwithstanding this the clerk in charge had recorded daily that the water inside and outside the cylinder was the same, which was palpably false.

On examining the tidal diagrams, the curves from the 1st November to the 5th December were found to be very much compressed, and consequently they were rejected. To avoid similar occurrences the Master Attendant, Captain Donnan, who takes great interest in the work, has very kindly undertaken to see that the pipe is removed and cleaned every fortnight, and also to have independent comparisons of the height of the water inside and outside the cylinder taken daily by some person other than the clerk in charge of the observatory as a check on the work.

The observatory was inspected by Lieutenant Longe between the 5th and 8th December, during which time the gauge was thoroughly cleaned in all its parts by the watch-maker of the party and left in perfect order.

The anemometrical and barometrical data are supplied by the office of the Surveyor General of Ceylon.

Galle.—The tidal observations have been very satisfactory, not a single failure in the observations having taken place.

The anemometer clock has failed to work on six occasions, twice in December for 17 and 21 hours and four times in January for about a day at a time. All these stoppages occurred shortly after the instrument had been cleaned by the watch-maker and the cause of them is not known; but since January the performances of the anemometer have been satisfactory.

In the old pattern self-registering aneroid by Adie, modified by Légé, there have been only two failures throughout the year, the first occurring on the 2nd March, when the clock stopped for four hours, and the second on the 16th June, when the clock again stopped for twelve hours.

No interruptions in the working of the new pattern self-registering aneroid by Légé and Co. have been reported.

An inspection of the observatory was made in the early part of December by Major Baird, accompanied by Lieutenant Longe, when the instruments were all thoroughly cleaned by the watch-maker and left in excellent working order.

At this port the operations have been much facilitated by the kindness of Captain D. Blythe, the Master Attendant, who takes great interest in the work and superintends the clerk.

Negapatam.—In the last Annual Report the very unsatisfactory nature of the tidal registrations at this port was mentioned, and it was found that the results deduced from the observations between the 5th December 1883 and 11th December 1884 were useless. Owing to the imperfect communication also mentioned therein, trustworthy observations were not obtained until the 20th March 1885, and the Negapatam tidal year has accordingly been changed so as to commence on the 20th March, and not on the 6th December as formerly. The observations for the year ending in March 1886 are satisfactory and the gauge has worked uninterruptedly, but since the beginning of the current tidal year a small but increasing difference is noticeable between the readings inside and outside of the float box which, at this observatory, is the substitute for a cylinder. Up to the present time this difference has only attained to 0·1 feet, and until the results of some special measurements which have been ordered have been received, it would seem to point rather to a subsidence of the graduated staff than to faulty communication. At latest this will be cleared up at next inspection. At a former inspection the Port Officer was requested to take check readings to a graduated staff unconnected with the observatory and he has forwarded the readings he took, but unfortunately they have not been found of a nature calculated to fulfil their object.

The self-registering anemometer and aneroid have not had a single break in their registration throughout the year.

The observatory was inspected conjointly by Major Baird and Lieutenant Longe in November last and all the instruments were cleaned by the watch-maker and left in good working order.

Madras.—The performances of the self-registering tidal gauge were satisfactory up to the 13th May last when the clock stopped working and was removed for repair by Messrs. Orr and Sons of Madras, who repaired it on the 18th, but the repairs were not properly executed, as it continued to stop very frequently. On the 23rd May there was very heavy rain and strong wind from the north-east which broke the float pipe, and the registrations were consequently stopped. Two days afterwards the instruments were removed into the Master Attendant's Office and the repair to the pipe was taken in hand. On the 4th June the pipe was re-fixed and the work was re-started the following day. On the 26th June the clerk in charge of the observatory, while flushing out the pipe, found that water had got into the float and that its bottom had given way. At the request of the Master Attendant, Sub-surveyor Dhondu Venayak and the watch-maker were sent to rectify the float. They found it necessary to repair the clock also, and on the 18th July the registration of the curves was resumed, and the instrument continued to work on till the 28th July, when the clock began to stop again, and on the 29th it stopped completely. Messrs. Orr and Sons examined and repaired the clock and on the 10th of August it was re-fixed, since which date no stoppage has been reported. They have reported that the vibration of the pier during the loading and unloading of cargo is so great that it may cause the clock to get out of order at any time. It was also noticed in the General Report for 1884-85, that the heavy traffic on the pier seriously interfered with the proper working of the clock.

The self-registering aneroid was brought away to Poona on the 4th June 1885. It was repaired by the watch-maker of the party, taken to Madras and set up on the 17th November, since which time there have only been two short interruptions in its registrations of 12 and 6 hours each, on the 26th March and 25th June.

There is no anemometer at work here, as the records of the Madras Observatory will be available when required.

Major Baird and Lieutenant Longe made an inspection of the observatory in November 1885 when the tide-gauge clock was taken off and cleaned and the self-registering aneroid was put up. I also inspected the observatory in February 1886, and Sub-surveyor Dhondu Venayak, when he went in July to repair the float, made a very full and complete inspection.

Cocanada.—The self-registering tide-gauge, anemometer and aneroid, which had been in use at Vizagapatam, were sent to Messrs. Légé and Co. for alteration and modification, and on their receipt from London were set up at Cocanada in March last, and the tidal registrations were commenced on the 31st of the same month. The Vizagapatam observatory house was also transferred to Cocanada. It has been set up on the eastern bank of the Godávari Canal, 20 feet from the bank, near the Master Attendant's landing jetty, and its floor is 3 feet above high water mark. The float cylinder from Vizagapatam being found too short, a box 3 feet high was added to it according to Major Baird's instructions, and let in through the floor of the observatory. A small bent pipe carrying a rose is attached to the float cylinder at about 9 inches from the bottom and about 2 feet below the lowest tides.

Since the starting of the work not a single interruption has taken place in the registration of the curves by the self-registering tide-gauge, and nothing remarkable occurred except on the 14th June last, when between 2 and 3-30 A.M., about low water, the diagram showed that there was a rush of water up the canal, and a similar occurrence took place between 10-45 and 11-45 the same morning also at low water.

The self-registering anemometer was set up on the roof of the Master Attendant's office, well above the surrounding buildings and trees; before this was done it was necessary to repair the toothed wheel of the barrel which was found broken when the instrument was opened. This was done by the watch-maker and it began working on the 8th April last, and had only one break of a day in its registration when the clock stopped on the 18th April. The watch-maker being on the spot it was attended to by him and no further stoppages are noted.

There is a small defect in its construction, which however does not affect the correctness of its registration, the pointer having been set by Messrs. Légé and Co., when repairing the instrument, to point from, instead of towards the quarter from which the wind is blowing.

The self-registering aneroid was set up in the Master Attendant's office, and although so recently repaired and modified by Messrs. Légé and Co., it was found in an unsatisfactory state—the gold band was broken and the hair-spring, which appeared to be the old one, was coated with rust and was not able to act properly. The watch-maker of the party repaired the instrument and it has since been working well, but a new hair-spring ought to be substituted for the present one at the next inspection.

The observatory was erected under the supervision of Captain Baker, the Port Officer, who, when he was at Pámban in the same capacity, greatly assisted the tidal observations there, and he is now continuing his kind co-operation. Finding a great part of the timber, screws and bolts of the Vizagapatam observatory so much worn away as to be useless, he replaced them by proper materials and had the structure properly erected, which owing to its distance from the bank was a troublesome business. The instruments were put up and the work started by Sub-surveyor Dhondu Venayak. The inspecting officer has to visit the observatory as soon as possible during the coming field season, but the Sub-surveyor carried out all the details of a full inspection before leaving the port.

Dublat.—The tidal registration at this port by the self-registering tide-gauge has been most satisfactory, not a single break or interruption in the work having taken place.

The self-registering anemometer also has worked very well. With the exception of a break of 10 hours on the 5th June and another of 4 hours on the 31st August, both due to the stoppage of the clock, the registration has been continuous. The old self-registering aneroid by Adie has worked very unsatisfactorily; there have been frequent stoppages of the clock, and scarcely a diagram is without breaks. The clock of this instrument being a pendulum one, is easily affected by the vibration in the observatory and any sudden shock stops it. It was cleaned in June last by the watch-maker of the party, but the record still continues to be very unsatisfactory.

The self-registering aneroid by Légé and Co., which was set up in December 1884, worked continuously up to the 13th January 1886 when it stopped, and as the observatory clerk had no way of getting at the balance wheel of the clock he could not re-start it. It was, however, cleaned by the watch-maker of the party last June, since which time it has been working well.

Mr. Belcham inspected the observatory last June, when the instruments and clocks were all thoroughly cleaned by the watch-maker and left in good working order A settlement of 0·225 feet has taken place in the observatory since the last inspection in February 1885, which no doubt is due to the extra weight of 4 sets of braces formed of old rails, which had been fixed to the piles in June 1885 to strengthen the observatory.

Diamond Harbour.—The tidal registrations at this port by the self-registering tide-gauge have been unsatisfactory for the past year. No less than 33 stoppages of the clock of the gauge were noted; these, however, lasted only from 3 to 13 hours on each occasion, and the breaks can therefore be interpolated. The copper band attached to the float stuck on 4 different occasions for about 6 hours at a time, and the breaks thus occasioned can also be interpolated.

The self-registering anemometer has registered continuously without a single interruption; and there have been only three interruptions in the registration of the self-registering aneroid caused in each case by the driving clock ceasing to work.

For a considerable time past the observatory had been in a very unstable and dilapidated condition, and used to sway according to the direction of the tide. It was reported

to be unsafe, and I accordingly made an inspection of it on the 23rd March 1886, and found by levelling that during the previous 7 months a subsidence of 0·414 feet had taken place in the bed plate of the gauge. Considering the time of the year, however, I decided to allow it to remain at work until the 12th April when 5 years' observations would be completed. Work was accordingly continued to that day, when all the instruments were dismantled by Lieutenant Petley, R.N., Deputy Conservator of the River, and brought away by him. They were afterwards taken over by Mr. Belcham and stored in the Mathematical Instrument Office, Calcutta.

I take this opportunity to acknowledge the great trouble Lieutenant Petley has always taken in helping on the work at all the Hooghly tidal stations.

The kindness of Major Boughey, R.E., Manager, Eastern Bengal State Railway, also calls for acknowledgment here. When I made my inspection, I was without departmental assistance, Sub-surveyor Dhondu Venayak and the watch-maker of the party being then engaged in putting up the instruments at the new tidal observatory at Cocanada. To assist me in the necessary levelling, Major Boughey most kindly sent an Assistant Engineer, Mr. Russik Lall Roy, who was most obliging and did all that was required in the most efficient way.

Kidderpore.—From the date of the last Annual Report to the 20th December the self-registering tide-gauge has worked well. The clock of this instrument stopped on nine different occasions, but as they were only of a few hours' duration each, the broken curves were easily filled up, and since December there has been only one stoppage of three hours which occurred on the 16th June. During the time under report the wire attaching the counterpoise weight to the pencil broke on three occasions; the first two breakages caused no interruption in the work, but the last one occurred about midnight and consequently the wire could not be renewed until the clerk came to his duties next morning, and 7 hours' work was lost.

Up to the 4th September 1886 the self-registering anemometer has worked with only five short breaks in its registration, which were all due to the stoppage of its clock. But from the 5th to the 11th of the same month the instrument stopped daily, and on the latter date it had to be removed by Lieutenant Petley, R.N., for repair.

The self-registering aneroid clock stopped ten times during the past year, but only for a few hours at a time.

The observatory was inspected by Sub-surveyor Dhondu Venayak in the beginning of May last when all the instruments were cleaned and left in good order; and a second inspection was made on the 14th of the same month by Mr. Belcham.

Chittagong.—The tidal registration at this port began on the 6th June last. The instruments set up in the observatory, with the exception of the mercurial barometer, are those that had been working at Moulmein up to the 24th April last.

Since the starting of the work and up to the present time, no failures of the self-registering tide-gauge have occurred. On two occasions the error of its clock was allowed to exceed three minutes. This was due to the circumstance that the observatory clerk had not a proper watch with which to note the time at the telegraph station. He has now been provided with one.

The self-registering anemometer and aneroid are working very well. Some hours' work was lost on the 27th June, owing to the barrel of the anemometer not gearing with the clock, and on the 22nd July the clock of the aneroid stopped for two hours.

The observatory house at this port is the one which formerly contained the Diamond Harbour instruments. Captain Stiffe, the Port Officer of Calcutta, who also exercises supervision over the port of Chittagong, arranged for the purchase of the structure by the Port authorities of the latter place from the Calcutta Port Commissioners. He also had a float cylinder constructed for the Chittagong gauge at the Government dock-yard at Kidderpore, and he selected the site for the observatory. It is due to him that it has been possible to commence tidal registrations so soon at Chittagong.

The observatory has been erected on the west side of the head of the iron jetty, and a special arrangement of chains has been devised to protect the cylinder from the timber, &c., brought down the river by the ebb tide, which here flows with great rapidity. The town and pier are situated on the right bank of the river, at a distance of about 9 miles from its mouth.

The observatory was erected and the instruments placed in position and started by Sub-surveyor Dhondu Venayak and the watch-maker of the party. Mr. Good, the Port Officer, took the greatest interest in the erection of the observatory, and engaged an observatory clerk whom he has promised to supervise. Although none of the fittings had arrived before the 20th May, by the end of the month all the instruments were in position. Sub-surveyor Dhondu Venayak remained at the observatory teaching the clerk his duties until the arrival of Mr. Belcham on the 26th June, who made a complete inspection of the observatory and left everything in perfect working order.

Elephant Point.—From the date of the last report until the 23rd December there were sixteen short breaks in the registration of the tidal curves by the self-registering tide-gauge, owing to the faulty working of the clock: these, however, can be easily interpolated, and since the latter date only three breaks of a few hours each have been noted. On the 23rd December the bed-plate was found to be out of level, and was set right by Mr. Jennings, the Port Engineer. Between the 9th and 11th January the observatory was somewhat neglected owing to the illness of the clerk in charge, and the clock was allowed to run into error to the extent of 6 minutes 16 seconds.

On the 3rd February, the wire attaching the counterpoise weight to the pencil, broke, but was renewed after three hours. On the 7th March, the tide-gauge clock and barrel were removed to be cleaned, thus occasioning an unavoidable loss of four hours' work; and finally, on the 13th July, the wire of the counterpoise weight again broke and five hours' readings were not registered.

The self-registering anemometer is in position on the top of the look-out house near the Telegraph Office. Since the date of report it has only worked for ten days. On the 16th November the clock broke, and was sent to Rangoon for repair, but the watch-maker to whom the work was given, after keeping the clock for almost four months, said he could not repair it, so I brought it away to Poona last March, where it has been repaired by the watch-maker of the party, and it is now ready to be sent back to Elephant Point.

The registration of the self-registering aneroid has been almost continuous, its clock having only stopped once on the 6th February last. The instrument remains for safety in the Telegraph Office and is attended to by Mr. Duckworth, the Telegraph Master, who has also the immediate charge of the anemometer, and exercises supervision over the tidal observatory clerk. Mr. Duckworth has shown himself interested in the work, and takes good care of the instruments entrusted to him, which could not have been said of his predecessor.

I inspected the observatory in March last, when the tide-gauge, the self-registering aneroid and the machinery of the anemometer, with the exception of its clock, were all thoroughly cleaned. I was accompanied and assisted by Sub-surveyor Dhondu Venayak and the watch-maker of the party.

Acknowledgments are again due to Mr. Jennings, the Port Engineer of Rangoon, for the assistance he still continues to give at this observatory in spite of its distance of 25 miles from Rangoon. It was mentioned in the Annual Report for 1884-85 that it would give some trouble to prepare the diagrams for July and August 1885 for the measurements; this is due to an uncertainty regarding the relative level of the bed-plate of the gauge and bench mark of reference during those months, consequent on a serious movement of the observatory on the 17th July, which was reported to Mr Jennings, who, according to the report of the observatory clerk, restored the observatory to its original level on the 1st September 1885. Mr. Jennings has been asked to furnish the levels he took in connection with this movement of the observatory, without which data the registrations from the 17th July to the 1st September cannot be used, but as yet he has not sent them.

Rangoon.—The self-registering tide-gauge worked very well until the 24th June last, up to which date there were only a few trivial interruptions in the registration curves caused by the clock failing to work. Also the band slipped off the stud wheel on one occasion, and thrice it got entangled in the float box. But on the above-mentioned date a serious accident happened to the observatory. In a letter dated 24th June from Mr. Jennings, the Port Engineer, which was forwarded by the Port Commissioner, it was stated that on the 24th June "the house on Latter Street wharf containing the tide-gauge was upset by the S. S. *Zephyr* this morning." The damage caused was considerable—the pendulums of the self-registering tide-gauge and aneroid clocks were broken, also the gold wire attached to the pencil marker of the latter, and the copper band of the float; the rain gauge, together with two tin cases, one empty and the other containing aneroid diagrams, were lost, and the roof of the observatory was broken. The repairs were immediately taken in hand by Mr. Jennings, who also got a watch-maker to attend to the instruments and clocks. On the 5th July the tide-gauge was re-started, there being thus a break of eleven days in the registration of the curves due to this accident; but until an inspecting officer can visit the observatory and take the necessary measurements, there is the fear that should a second mishap occur, all the registrations between the 5th July and the possible future interruption would be rendered useless.

The self-registering anemometer was stated in the last Annual Report to have been working unsatisfactorily, and from that time only seven weeks' continuous work has been registered by it, namely, until the 1st January, when, owing to the fly wheel of the clock being broken and worn out, it became quite useless, and a few days afterwards the clock was sent for repair to the same watch-maker who had undertaken the repair of the Elephant Point anemometer clock, and with a like result. He was unable to repair it, and I brought it away to Poona, where it has been recently repaired by the watch-maker of the party.

The self-registering aneroid worked continuously from the date of the last report up to the 24th June last, when the accident to the observatory, which has already been mentioned, occurred. The gold wire attached to the pencil marker and the pendulum of the clock broke on that occasion; but they were repaired by the 6th July, since which time no stoppages have occurred.

Accompanied by Sub-surveyor Dhondu Venayak and the watch-maker of the party, I inspected this observatory in February last. The instruments were thoroughly cleaned, and with the exception of the anemometer, which could not work without its clock, they were all left in good working condition.

Acknowledgments are again due to Mr. Darlington, the Vice-Chairman of the Port Commissioners, for his continued assistance, and to Mr. Jennings, the Port Engineer.

Amherst.—There have been no stoppages in the registration of the self-registering tide-gauge throughout the year, with the exception of the brief but necessary interruptions caused once a fortnight by the flushing of the float cylinder.

In the registration of the self-registering anemometer there have been only four

interruptions, one of a day and the other three of a few hours each, all owing to the stoppage of the clock.

The self-registering aneroid has worked continuously throughout the year.

This observatory was inspected in February and March 1886 by myself, accompanied by Sub-surveyor Dhondu Venayak and the watch-maker of the party, and all the instruments were cleaned thoroughly and left in good order.

This observatory was originally started on the 30th July 1880, and the calculations of the tidal constants commenced from the 5th of the following month, that being the date of new moon. In the Annual Report for 1881-82 it was remarked, with reference to the first year's observations :—"The present co-efficients are deduced from the observations taken during eight complete lunations from 5th August 1880 to 29th March 1881, and they are therefore not of the same value as if they had been derived from a year's good work." After a break of upwards of four months, the second year's registration began on the 5th August 1881, and it has been thought well to have a complete series of five years' observations from that date before closing the observatory. The period was completed last month, and Captain Dodd, the Port Officer at Moulmein, has accordingly been requested to close the observatory, and directions have been sent him as to the packing and present disposal of the instruments, which are intended to be sent to Akyab when the arrangements regarding the establishment of a tidal observatory there have been made.

Moulmein.—The self-registering tide-gauge worked continuously since the date of last report, with the exception of one short interruption of seven hours on the 8th October, when the clock stopped.

The tides at this riverain port are very peculiar, and it was thought well to extend their registration over a period of six years This period was completed on the 24th April 1886, and all the instruments were then dismantled by Captain Dodd, the Port Officer, and sent to Chittagong for erection there.

The self-registering anemometer and aneroid have both worked very satisfactorily since the dates of last report, not a single failure having occurred.

An inspection of the observatory was made last February and March by myself, accompanied by Sub-surveyor Dhondu Venayak and the watch-maker of the party, when all the instruments were found in good order and working most satisfactorily. As a preliminary to their removal they were thoroughly cleaned, and Captain Dodd, the Port Officer, arranged to dismantle them on the period of the observations coming to an end, and after packing them carefully to forward them to Chittagong. As the wharf on which the observatory stood was undergoing demolition, he arranged that the outer part, supporting the observatory, should remain undisturbed until the instruments were removed; and he also had boats moored in such a way as to avoid all danger of shocks to the observatory from floating timber, &c. Special thanks are due to him for the great interest he has always taken in the work, and for the assistance he has so freely given it. The success of the observations at both the Moulmein and Amherst observatories is mainly due to his untiring supervision.

Port Blair.—There have been several breaks in the registration of the tidal curves by the self-registering tide-gauge since the date of the last report. The first of any importance occurred between the 16th and 18th November, when the float cylinder was being repaired, and a second of four days' duration between the 8th and 12th December, when, owing to the condition of the old cylinder, it had to be removed and a new one fitted. In addition to these there were twelve brief interruptions due to the stopping of the clock, but these were of no importance.

The self-registering anemometer and aneroid have both worked continuously since the date of last report.

No inspection of this observatory has been made since December 1884, and no occurrences worth mentioning beyond those already noted, have taken place since the date of last report, except that a slight shock of earthquake was reported to have been felt at 1-45 P.M. on the 26th September 1885, and another at 4 P.M. on the 12th January 1886, but neither of these caused any disturbance of the tidal curves.

BENCH-MARKS.

Up to the present time only three standard bench-marks giving planes of reference accurately determined by the tidal and levelling operations of this department, for general use in engineering undertakings in the large towns, have been established in India. The one first laid down is in Madras, on a stone at the north-east corner of the plinth of the light-house: it is described in Madras Government Order, dated 24th March 1885, No. 737 W. Public Works. The other two are in Bombay; one in front of the Public Works Offices on the Esplanade, and the other on the sill of the Prince's Dock. The former is described in Public Works Notification No. 57, dated 24th July 1886, published in the Bombay Government *Gazette* of the 27th July 1886, Part I, page 629. The erection of the standard bench-mark for Bombay was reported in the last Annual Report (see p. lx). It was examined by Mr. Belcham last January, who found it to be 0·27 feet too high. After the level of its surface had been reduced by that amount, it was verified by him on the 5th July, and on his reporting that it was quite correct, the Government Notification was published.

In the last Annual Report it was mentioned that a standard bench-mark for Rangoon had been built in the vicinity of the tidal observatory there; but it has not been connected by spirit-levelling with the observatory, nor has any inscription been placed upon it as yet. When I made my inspection of the Rangoon tidal station in February last, I found that the standard bench-mark, which consisted of a large block of masonry, had been built too high, and I considered that a change in its design would be an improvement. It was explained to me that the height had been given to render it difficult for people to climb on to the block, and consequently as a protection to its upper surface, which was to be the plane of reference; but I hope that the change I have made in the design will with a less height afford increased protection to the level surface of reference. Mr. Jennings, the Port Engineer, kindly carried out the alteration. The inscriptions on the standard bench-mark, and its connection with the tidal observatory, will be arranged for at next inspection.

In September 1884 the Deputy Superintendent, in charge, Trigonometrical Branch, ordered the establishment of "permanent bench-marks on reliable ground within a few miles of each tidal observatory in connection with the question of subsidence of land." A pair of such bench-marks were laid down during the past field season at each of the following tidal stations, *viz.*,—at Negapatam, Pámban, and Tuticorin. During the preceding field season pairs of bench-marks of this kind, which for convenience have been termed "test bench-marks," were laid down at Beypore and Madras, so up to the present time five pairs of test bench-marks have been established.

At the new tidal stations at Bhávnagar, Cochin, Cocanada and Chittagong, the usual bench-marks of reference were laid down and connected with their respective tidal observatories; and in addition to them 45 embedded bench-marks, 332 minor bench-marks, 11 Railway bench-marks, and 24 Trigonometrical Survey stations were connected in the course of the levelling operations of last field season.

At Tuticorin a new bench-mark has been laid down to serve as a substitute for bench-mark No. 2 to which the zero of the tide-gauge had been originally referred, and which was the initial point of the line of levels between Tuticorin and the Cape Comorin base-line. This appeared necessary in case the latter bench-mark, which is inconveniently situated and liable to damage, should ever become displaced. The new bench-mark was embedded by Mr. Corkery at a distance of about a chain from the old one, in the verandah of the Port Office, in a convenient and safe position immediately under the staircase, and was connected on the 20th June: its level is 2·518 feet above that of bench-mark No. 2.

While connecting the old bench-marks at Tuticorin, Mr. Corkery found that bench-mark No. 4, which was denoted by a stone post at the north-west corner of the pedestal of the cross in front of the Goa church, had disappeared.

When the Amherst tidal observatory was inspected in February last, it was found that a considerable subsidence had taken place in bench-mark B, which had been cut on a wooden post forming one of the supports of a small timber *Ziyat* or rest-house. This structure is in a rather dilapidated and unstable condition, and bench-mark B is quite useless for reference. There appeared to have been also a slight settlement in bench-mark C at the same observatory, and the position in which it lies may account for this. The other two bench-marks (A and D) at the Amherst tidal station are, however, good for reference.

LEVELLING OPERATIONS.

The programme of the season's work was as follows:—To carry a line of spirit levels from Madras skirting the coast to Negapatam tidal station and thence to Tuticorin tidal station, touching at Pámban tidal station, after which the line was to proceed northwards *viâ* Madura and Trichinopoly (with a branch line from the latter station to Negapatam) to Erode, where a connection had to be made with the levels run during 1884-85. Permanent bench-marks had to be established a few miles inland from each tidal observatory, where not already done, with as many connections as could conveniently be effected between the new lines of levelling and the triangulation, in order to make the heights of the latter as perfect as possible before publication. This programme would have involved an out-turn of close on 900 miles.

Although the levelling was started by Lieutenant Longe and Mr. Belcham, who did the first few miles in Madras, the total out-turn may be credited to Mr. Corkery, who was placed in charge of the levelling detachment, and who had as his assistant Sub-surveyor Narsing Das. Mr. Corkery took the field on the 3rd November 1885, preceded by Narsing Das, who had to meet at Sholápur the *khalassies* (carriers) who had been sent on leave at the end of the previous field season and take them on with him to Madras; and they returned to Poona on the 26th June 1886. During this exceptionally long field season, in spite of delays at its commencement from bad weather, and consequent sickness among the native establishment, a proportionately large out-turn of work was accomplished. It amounts to no less than 526 miles of double levelling, in doing which the instruments were put up at 3,709 stations, and in the course of which 394 bench-marks and 24 Trigonometrical Survey stations were connected. This is the largest out-turn on record with the exception of Mr. Belcham's out-turn of 533 miles during the previous season. Mr. Corkery's work was completed in three sections. The first section was from Madras *viâ* Tanjore to Negapatam; the second section from Tanjore *viâ* Ramnad to Pámban with a branch line to Rámesvaram; the third section from Ramnad to Tuticorin.

There now remains as a progamme for the coming field season the completion of the programme above mentioned, together with work on the west coast of India, all of which may be divided into sections as follows :—

	Miles.
From Tuticorin to Madura	99
„ Madura *viâ* Trichinopoly to Tanjore	127
„ Trichinopoly to Erode	87
„ Shoranur to Cochin Tidal Station	80
„ Kárwár to Mormugáo Station	50
„ Branch lines to Trigonometrical stations of the Great Arc and Konkan Meridional Series	25
Total	468

The results of Mr. Corkery's work do not tend to show that there is any appreciable difference between the mean level of the sea at his stations along the eastern coast. According to his results the mean sea-level at Negapatam is higher by 0·573 feet than the mean sea-level at Madras which by the line of levelling is 268 miles to the north, and it is also 0·270 feet higher than the mean sea-level at Pámban, which by the line of levelling is 191 miles to the south. Also, the mean sea-level at Tuticorin is higher by 0·169 feet than that of Madras, the distance between these two places being 408 miles. Such small discrepancies as these may be due to other causes than differences in the sea-level. If distributed over the lines of level in question, they would give, in the first section, an error of only ·0021 feet per mile, while in the other two the error per mile would be still less.

The following extracts are taken from an interesting report on his work submitted by Mr. Corkery :—

"Mr. Belcham and I left Poona on the 3rd November, and were obliged to stay at an hotel in Madras, pending the arrival of our kit, which reached us on the 8th."

* * * * *

"On the 8th November the instruments were overhauled and tested, and the staves compared with the standard bar. On the 9th levelling operations began from the tidal observatory at the end of the pier; Lieutenant Longe and Mr. Belcham worked the cylindrical level, and Narsing Das and I the rectangular. Progress was slow at first; the portion between the Madras pier and St. Thomas' Mount, a distance of 10½ miles, and a visit to the Trigonometrical station on the summit of the Mount, occupied us for five days; each day we left camp at 3-A.M., returning at 1 or 2-P.M., and on one occasion at 5-P.M. The difference between the closing values of the two instruments over this short distance was as much as $\frac{9}{100}$ of a foot, or a little over one inch."

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"Incessant rain for a week from the day after Mr. Belcham left us, retarded work; and what was worse, sowed the seeds of disease in many of the men, which hampered the work at times. No house accommodation could be obtained, and as we were encamped in low-lying country—the only available spot near the Railway line—I set the men to work to drain the place, and to raise the flooring inside their tents to a height of 8 inches; they were also provided with mats to keep out the cold and damp.

"On the 20th November we resumed work, and with the exception of an occasional break of a day or two on account of rain, and four days at Christmas, work went on steadily, the first section, along the Railway line *viâ* Tanjore, closing at Negapatam on the 4th March. The distance levelled in this section was 283¾ miles, including 15¼ miles of branch lines to Trigonometrical stations. The height of G. T. S. Bench Mark *A*. at Negapatam, the closing point of the 1st section, was found to be 10·156 feet above mean sea-level at Madras: its height above mean sea-level at Negapatam is 9·583 feet. This either shows Negapatam mean sea-level to be 0·573 feet above Madras mean sea-level, or, if the error lies in the levelling operations, it is an error of ·0021 feet per mile. In this section 28 bench-marks were embedded, including two test bench-marks: 230 minor bench-marks inscribed on advantageous positions were connected, also 9 Trigonometrical stations of the Madras Coast Series and of the Negapatam Minor Series: test bench-marks were laid down near Kivalur Railway station, 7 miles from Negapatam, one on each side of the line of levels and respectively one mile north and 50 chains south of the main line.

"Section II was started on the 8th March and completed on the 13th May. It emanated from the embedded bench-mark at Tanjore, of Section I: proceeding *viâ* Arantángi and Mimisal to Ramnad where a bench-mark was embedded; the section closed at Pámban, on bench-mark *A*. The closing value of this bench-mark is 7·774 feet above Madras mean sea-level, and 7·471 feet above Pámban mean sea-level. The value of Pámban mean sea-level so deduced is therefore 0·303 feet above Madras mean sea-level, and 0·270 feet below Negapatam mean sea-level. The distance levelled in this section, including 12 miles of branch lines to Trigonometrical stations, was 154¾ miles. The total distance from Madras to Pámban *viâ* Tanjore and Ramnad is 361 miles; the error in levelling =0·303 feet or 0·0008 feet per mile. A branch line 8¾ miles long was run from bench-mark *C* at Pámban to the extreme end of Rámesvaram island, closing on a bench-mark inscribed at west entrance to Rámesvaram temple. Gandhamána Temple station, and 11 other Trigonometrical stations of the Madras Coast and Ceylon Connection Series were also connected.

"Test bench-marks were embedded near Perapanvalasai Chattram, 10 miles from Pámban, one on the line of levels, and the second 32 chains north. Twelve embedded bench-marks, and 74 minor inscribed bench-marks were connected by levelling in this section.

"Section III, emanated from the embedded bench-mark at Ramnad of Section II, and closed at Tuticorin on a new bench-mark near G. T. S. B. M. No. 2 ⋀A. D. 1869. The distance levelled in this section was 78½ miles, including 4 miles of branch lines; it occupied the party from the 17th May to the 20th June. The value of B. M. No. 2 above Madras mean sea-level is 4·569 feet, and above Tuticorin mean sea-level is 4·400 feet, shewing Tuticorin mean sea-level to be 0·169 feet above Madras mean sea-level. The distance from Madras to Tuticorin along the line of levels is 408 miles; the error per mile of levelling is therefore 0·0004 feet, if the mean sea-level at Tuticorin, as determined by Colonel Branfill in 1871-72, may be accepted as its present value.

"Nine embedded bench-marks, including two test bench-marks, and 36 minor points were connected, also 3 Trigonometrical stations of the Ramnad Longitudinal Series. The test bench-marks for Tuticorin were laid down 12 miles inland from Tuticorin, one on each side of the line of levels and 1½ and 1¼ miles respectively from the main line.

"The districts traversed were very healthy, but owing to the heavy rain which we had at St. Thomas' Mount at the commencement of the work, many of the men suffered severely during the early part of the

season. I regret exceedingly to have to record the death of Sub-surveyor Gunesh Sudasheo early in the season. He was the most intelligent Sub-surveyor I have met; in addition to being a rapid recorder and accurate computer, he was able to work both levels. * * * * *
He was a great favourite in camp, and every one regretted to hear of his premature death.

"Four *Khalassies* (carriers) also were seriously ill early in the year, and at one time there was very little between them and death."

"Every man but one in camp had his turn of illness."

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"I beg to acknowledge the great courtesy shown, and the help given, by every one of the officers of the S. I. Railway with whom I came in contact; it enabled the work to proceed without a hitch. We were equally well treated when we left the Railway line and levelled from Tanjore to Tuticorin: there was one notable exception, and that was in the Zemindari lands of Ramnad. Carts were refused us, and every obstacle thrown in our way when buying supplies. *Dasturi* was demanded in Ramnad itself from the cartmen who had voluntarily agreed to come with us. As they declined to pay, they were prevented from coming to my camp.

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"With one exception I experienced no difficulty in the levelling operations of the season; the exception was in crossing the Pámban channel. Luckily we hit upon the most favourable time of the year as regards lowness of tides. The rocks on which the instruments were set up by the previous leveller, near the deepest part of the channel, no longer exist, and we had much difficulty in securing a favourable spot; at one station the staves were 32 chains apart. Narsing Das was unable to observe to his satisfaction a staff 16 chains distant, so I worked both instruments, taking half a dozen sets of observations with each instrument, using the usual staves; and two or three more with each instrument when using Colonel Strange's pattern staves, divided to tenths of a foot. Every chance of error was eliminated by the number of sets of observations. The width of the channel is a mile and a half, and it took us three days of hard work to level across. Our difficulty lay in measuring distances; for this purpose ropes, previously divided into chains and half chains, were used. It took us two days to circumvent the deep water channel, which is about 18 chains wide. The tide was so terrific that no boat succeeded in carrying the measuring rope across. On the second day when we almost despaired of success, a boatman gallantly swam across with the rope. The distance from the platform of the Toni Turai Chattram on the mainland to the nearest point of Pámban island, as measured this year, is *m.* 1, *ch.* 39, *l.* 46, the previous record was *m.* 1, *ch.* 40, *l.* 90. The height of Toni Turai G. T. S. B. M. exceeded the value obtained in 1879 by nearly half an inch.

"No sign of the letters G. T. S. B. M. inscribed on the Toni Turai platform in 1879, could be found when visited this year: they had apparently been covered with a coating of lime. I was not permitted to remove this, and my levels were taken to the surface; but as the coating of lime was nearly half an inch thick, the difference of half an inch between the values of 1879 and 1886 disappears. A bench-mark was embedded in the Chattram and connected.

"Gib's monument, which is within 10 yards of the water's edge, was connected on both occasions, the value for 1879 was — 1·674, and for 1886, — 1·912, or a difference of — 0·238. The monument is visibly sinking; it is already ten degrees out of the perpendicular; this explains the difference in value of — 0·238 feet."

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"An abstract of the season's work is attached to this report: it shows that 526½ miles of double levelling were completed, including 42 miles of branch lines, which I may add are more troublesome than main lines. The total of rises and falls was 3,276 feet: 74 Trigonometrical stations were connected, 58 bench-marks were embedded, and 332 minor bench-marks were inscribed on prominent points; 15 Railway bench-marks also were connected.

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"It is superfluous to attempt a description of the country passed through. I may mention, however, that, during the months of April, May and June, large quantities of pumice were washed ashore, first making their appearance at Rámeswaram and Pámban, and gradually finding their way up towards Madras. I collected a few specimens, some of them with coral growths on them. I offer as a conjecture that they are the remnants of the upheaval at Krakatoa some three years ago.

"A visit to Pámban and its neighbourhood will well repay the naturalist. Living corals are found in abundance 4 miles south-west of Pámban Light-house; their glorious colourings are beyond my powers of description. It is not often that the living coral is to be found so near the mainland, as a condition of his existence is a pure sea, free from the pollution of rivers, &c. There are not many varieties of coral; I saw but five or six, and of these the Meandrina, or Brain coral, and Oculina predominate.

"The following is a rough classification of those found:—

Actinozoa	1. Zoantharia, comprehending	Sclerodermic forms
	2. Alcyonaria ,,	Sclerobasic ,,

Of Sclerodermic forms the Brain coral and Oculina were found in abundance. Of Sclerobasic forms I picked up a couple of specimens of the handsome Organ-pipe coral (Tubipora).

"At Pámban I was presented with a piece of coral called the "Biscuit coral," but which I believe is not indigenous. My impression is that it has not as yet been classified, and I am sending the specimen to a specialist for information. Echinoderms are also found in abundance; the common star-fish, and the Ophiurid, or brittle star, but neither calls for remark.

"At the Rámesvaram end of the island, during the course of a couple of sea-side rambles, I picked up eleven varieties of sponges, washed up from their ocean homes. They are said to grow within a few hundred yards of the island. One of the sponges has in all probability a market value. Like the ordinary sponge of commerce, it has a horny support of true spongiolin, its pores and oscula are smaller than those of the bath sponge, though not comparable with the Turkey sponge. I have kept this specimen for further enquiry. The other sponges were the usual simple oceanic forms with Siliceous supports.

"At Rámesvaram an extensive and very profitable trade is carried on in '*chanks*'. These shells are brought up by divers from considerable depths; they are trans-shipped to Calcutta whence they are distributed throughout Northern India. They play an important part in the religious ceremonies of the Hindu; any water, however impure, becomes purified and sacred, from the fact of its having been poured into the shell. I found to my surprise that the Mahomedan also uses it here as a 'Konch' and blows his blast with it to summon the faithful to prayer.

"Early in January I found the sea-shore covered with jelly-fish-like forms, the size of a large cherry; they had evidently been washed up after a storm. They belonged to the group of 'physophoridæ', genus

Porpita. The disc was marked with concentric rings, intersected by radiating bars, the latter cutting it into wedge-shaped chambers: each chamber was filled with the gas which gives this genus its peculiar light-blue tint. Attached to the float (pneumataphore) was a long tentacle crowded with thread cells.

"I beg to draw attention to the disappearance of Porto Novo chimney on the 11th January of this year: it is given on the charts as an intersected point of the Trigonometrical Survey."

Tabular Statement of out-turn of work for the Field Season 1885-86, by the Levelling Detatchment under Mr. H. Corkery.

During the month of	Number of miles, double levelling. Main Line.	Number of miles, double levelling. Branch Line.	Total number of feet. Rises.	Total number of feet. Falls.	Number of Stations at which the instrument was set up.	Number of Bench-marks embedded, inscribed and connected. Ordinary Embedded.	Test B. Ms. Embedded.	Inscribed.	G. T. Survey Stations.	Railway B. Ms.
	Ms. Chs. Lks.	Ms. Chs. Lks.	Feet.	Feet.	No.	No.	No.	No.	No.	No.
November 1885	39 40 84	1 38 10	561·1	216·8	288	4	...	37	1	...
December ,,	65 0 88	6 39 23	1068·7	415·4	458	7	...	53	2	...
January 1886	90 62 38	. . . .	217·9	261·5	550	9	...	72	...	4
February ,,	73 45 90	4 78 62	505·7	331·9	543	6	2	68	4	7
March ,,	55 79 78	11 57 78	658·4	601·5	528	5	...	23	7	...
April ,,	76 51 24	2 1 16	465·8	526·7	566	5	...	31	5	...
May ,,	49 14 66	12 41 6	552·7	397·4	517	5	2	22	5	...
June ,,	33 44 58	2 64 20	240·9	253·5	259	4	2	26	...	...
Totals	484 20 26	42 0 15	4271·2	3004·7	3,709	45	6	332	24	11
Total number of miles double levelling	526 20 41		Total of risesand falls.	7275·9						

Revision of the heights of the South Konkan Meridional Series.

In his sanctioned programme for the field season 1885-86, the Deputy Surveyor General, in charge Trigonometrical Branch, remarked:—

"The heights of the South Konkan Series (from Bombay to Goa), determined trigonometrically over 40 years ago, being unsatisfactory and defective from the circumstance of the observations being confined to only certain rays of the triangulation, and not having been made in such a manner as to overcome the uncertainties of terrestrial refraction (more especially necessary as one flank of the series skirts the sea coast while the other rests on the *ghâts*), it is necessary to re-measure the heights of this Series—some 270 miles in length—before the final publication of the heights of the Southern Trigon."

He subsequently gave instructions that Lieutenant Longe and Mr. Prunty should be employed on this work and added—

"They will be required to observe *simultaneous* verticals on each *cross* ray of the series, and ordinary verticals on the flank rays."

As Lieutenant Longe had to leave the party in December to take the charge of the South Marátha Survey, it became necessary to employ Mr. Belcham in his place on the revision of the heights, in addition to his other duties.

Mr. Belcham left Poona for Madras on the 2nd November and remained with the levelling detatchment, starting the work until the 14th November, when, according to Major Baird's instructions, he took a set of zero measurements at the Madras tidal observatory and then made all possible haste back to Poona, arriving there on the morning of the 15th November, and commenced his preparations to take up the revision of the heights of the South Konkan Meridional Series in conjunction with Mr. Prunty. Mr. Prunty, whose establishment preceded him into the field, left Poona on the 20th November, but Mr. Belcham was unable to leave so soon, as the instruments intended for his use, sent from the Mathematical Instrument Office in Calcutta, did not arrive in Poona until the 21st November. After some delay in Poona through having to repair the stand of his 14-inch theodolite which had been broken in transit, and a further short delay after arriving on his ground in arranging a code of flashing signals with Mr. Prunty, simultaneous observations were commenced on the 27th November.

A few days at Christmas were employed by Mr. Belcham, according to his instructions, in making inspections of the tidal observatories at Bombay and Bhávnagar, and in verifying the standard bench-mark in Bombay; those days Mr. Prunty was consequently able to take as holidays. An inspection of the tidal observatory at Mormugáo was also made by Mr. Belcham while Mr. Prunty was making an exceptionally long march between two of his stations. Fifteen days were lost in consequence of a dense haze which set in about the middle of February—so that the two observers did not complete their vertical observations until the latter end of April. They then returned to recess quarters, arriving in Poona on the 1st May, since which time Mr. Prunty has been employed in the office on the computations connected with the height revision, together with the other work mentioned above. Mr. Belcham, on arriving in Poona, received instructions to go on to Calcutta on the tidal duty mentioned in paras. 32 and 33, and he returned to Poona in time to relieve Major Hill on the 25th May.

The work done conjointly by Mr. Belcham and Mr. Prunty consisted in revising the heights of the 18 principal stations which form the South Konkan Meridional Series, and the height also of one secondary station of that series which had to be visited and used as an auxiliary station in the course of the work. According to the Deputy Surveyor General's orders, simultaneous vertical observations were taken on the cross rays, and ordinary reciprocal vertical observations on the flank rays. Most of the cross rays were from 35 to 40 miles in length, seven of them exceeded 40 miles, and the ray between Kumbhárli H. S. and Kanta H. S. was 54½ miles long. The flank rays ranged in length from 23 to 39 miles.

The stations of the east flank of the series, which rests on the *ghâts*, were observed at by Mr. Belcham; and those of the west flank, which skirts the sea coast, were observed at by Mr. Prunty. The following table gives the heights of the stations as originally determined, and as now deduced from the recent observations; the latter values cannot, however, be considered final until the height of a station near the southern end of the series has been connected with the spirit-levelling. It is proposed, as stated in para. 53, to have this done during the coming field season :—

Name of Station proceeding from North to South.		Original height given in Preliminary Chart.	Height by Revision, 1885-86.	Error in Original heights.
		Feet.	Feet.	Feet.
East Flank.				
Mándwi	H.S.	4'123	4119·0	+ 4·0
Torna	„	4,605	4600·2	+ 4·8
Mahábaleshvar	„	4,717	4712·8	+ 4·2
Kumbhárli	„	3,435	3437·5	— 2·5
Manoli	„	3,348	3351·9	— 3·9
Valvan	„	3,240	3237·2	+ 2·8
Chaukola	„	2,778	2776·7	+ 1·3
Salili	„	2,019	2006·1	+12·9
Kumbhári	„	2,889	2880·5	+ 8·5
West Flank.				
Karanga	H.S.	997	*996·5	+ 0·5
Titvi	„	1,302	1315·8	—13·8
Kanta	„	1,100	1125·3	—25·3
Adhúr	„	352	371·3	—19·3
Mirya	„	464	463·8	+ 0·2
Ghirya	„	319	320·3	— 1·3
Bhutoba	h.s.	367	371·2	— 4·2
Parule	H.S.	517	512·5	+ 4·5
Agoada	S.	256	238·2	+17·8
Pil	H.S.	1,568	1551·0	+17·0

* Derived directly by reciprocal vertical observations to and from Trombay H. S. whose height was determined by spirit-levelling.

Considering the age of the stations of the South Konkan Meridional Series, and that none of them had been closed by protecting pillars, the condition in which they were found last season was better than might have been expected. Only four of them showed signs of dilapidation or of having been tampered with—these are Valvan on the east flank, and Kanta, Ghirya and Parule on the west flank. At Valvan H. S., the upper mark-stone, and all the masonry portion of the station had been destroyed; and Mr. Belcham found a pole and brush signal standing on the circle and dot which are engraved on the rock *in situ*. He built the station up to the level of the existing mark only. At Kanta H. S., Mr. Prunty found a '*kacha*' (stone and earth) circular pillar, 2 feet in diameter and 3½ feet high, containing no mark-stone and surrounded by a platform of loose stones. On removing it, he found the mark whose height is given on the preliminary chart, and which consists of a circle and dot engraved on the rock *in situ*. After completing his observations at the station he built a solid masonry pillar of the same dimensions as the one he removed, with a new mark-stone in the centre of its upper surface, exactly over the old mark. This was unnecessary, and confusion may afterwards arise unless care is taken, when the final heights are published, that the height of the new mark is given. The values entered in the foregoing table refer to the old mark on the rock *in situ*. At Ghirya H. S., Mr. Prunty found at the spot formerly occupied by the circle and dot, a hole 19 inches deep and 12 inches in diameter, bored in the solid rock, in which was standing a staff, 20 feet high, which he conjectures may have been erected for Marine Survey purposes. He also found three rubbed surfaces on the rock, the lines joining which, 2 feet in length, formed an equilateral triangle, having the hole at its centre—these evidently marked the positions for the feet of the stand of the theodolite. He further verified the position of the mark by means of the azimuths of the surrounding stations, and being satisfied of its correctness, he then filled in the hole and placed a new mark-stone in the exact position of the original mark, flush with the top of the hill. At Parule H. S., there was no upper mark, and Mr. Prunty built the protecting pillar over the lower mark-stone.

All the principal stations observed at by Mr. Belcham and Mr. Prunty were regularly transferred to the custody of the village officials in accordance with departmental regulations, after they had been closed with the usual protecting pillars. Bhutoba h. s., which was used as an auxiliary station, has been left protected by a cairn of stones.

The following are some extracts from Mr. Belcham's report on his season's work :—

"I observed at the stations on the east flank of the Series, they were nine in number and were visited in succession beginning at the north, and were as follows :—Mándwi H. S., Torna H S, Mahábaleshvar H. S., Kumbhárli H. S., Manoli H. S, Valvan H. S., Chaukola H. S, Salili H. S., and Kumbhári H. S.; of these Mahábaleshvar and Chaukola were very convenient as I was able to encamp within a short distance of each, but the remaining ones being on peaks, very remote from any habitation and devoid of water and being the haunts of wild beasts, such as tigers and bears, I considered it more prudent to remain at the foot of them, which necessitated a two hour's climb every morning as long as the observations lasted at each, and a run down the hill in the evening. Even at the foot of these stations, bears on several occasions paid my camp nocturnal visits and dug up ant-hills within a few yards of the tents, and the roar of a tiger often disturbed our slumbers.

"On the last day of the observations at Kumbhári H. S, I determined upon bivouacking on the hill for the night so as to get on with the closing pillar early the following morning, and we had scarcely retired to our impromptu huts, constructed of timber and grass, when we first heard a tiger and then followed a stampede of very large animals quite close to our bivouac; probably they were bison, which are said to abound in the hills immediately above the Konkan plain."

"The stations I visited are all very easy of approach, though the routes taken from one to another were very circuitous, and in most cases three times the direct distances owing to the absence of roads."

"The march to Kumbhárli from Mahábalesvar occupied six days: there being only a path across the hills, I had to follow the more circuitous road *viá* Sátára, Tárla and Pátan, by which it was over 90 miles, whereas in a direct line the distance was not more than 35 miles. On ascending the *ghát* at Tarla, the road suddenly narrowed and was only about 9 feet in width, and having camels for the carriage of my baggage, the distance between Tárla and Pátan was accomplished with the greatest difficulty and risk. The camels got into the gorge at the top of the *ghát*, but they could not pass through laden. Fortunately there was a village close by whence I got a number of coolies to carry the things down till the road became safer, but even then the camels cost me many an anxious moment as the road was very much cut up and the slightest slip on their part would have hurled them down a precipice some hundreds of feet below; however they got safely down to Pátan, where I got on to the high road to Chiplún, and reached Helvak, a village of some importance, immediately at the foot of Kumbhárli H. S.

"At Valvan H. S. the observations were not completed till the 3rd March, owing, in the first instance, to the introduction of another station (Bhutoba h. s.) between Ghirya H. S. and Parule H S. as the signal on this ray was not visible, though it had been observed when the triangulation was first carried out; and then to the very hazy state of the atmosphere, the like of which had never come under my experience before. The introduction of Bhutoba h. s. entailed the observing of the horizontal as well as the vertical angles, and though I had observed to Ghirya on the 18th February, when not only the heliotrope but the hill itself was distinctly seen, I did not again see the signal until the 26th, owing to haze, which was so thick that the hill tops within 8 or 10 miles became obscure: a sudden change, however, in the weather brought on a few clouds which, combined with a change in the direction of the wind, dispelled the haze, and on the morning of the 26th the distant objects became as clear as possible, and it was a welcome sight to see the signals at the surrounding stations after so many days of, I may say, darkness and anxiety. From Bhutoba h. s. Mr. Prunty proceeded to Parule H. S., while I remained at Valvan H. S. for the simultaneous observations, and, to our great annoyance, the haze again set in as dense as ever, and we saw nothing of each other's signals until the 3rd March, when it cleared up, and we were able to get through the observations the same afternoon.

"The hill of Salili being detached from the line of *ghâts*, I had to get down into the Konkan *viá* the Pám-ghát pass, which, though a good width, is very steep and stony, and the descent quite knocked up the camels, which necessitated a halt of a couple of days at the foot of the pass. The observations at Salili H. S. were started on the 22nd March, and by the 30th the vertical angles to Chaukola, Parule, Agoada, and Kumbhári were completed with great difficulty, as hazy weather, similar to that which retarded the observations at Valvan, was experienced. The signal at Parule appeared as a star of very small magnitude, and could only be distinguished by setting the instrument both in azimuth and altitude, and then it was a very flickering object; this ray was over 46 miles in length; for four days we could not exchange any signals, and neither observer knew whether the other had been successful in getting any observations, so that messengers had to be employed for communicating with each other. After this the villagers began burning the jungle on the low hills in the Konkan which made the atmosphere very much more hazy, so it was fortunate that we finished with this long ray as early as we did, or it might have been left unobserved.

"The observations at Kumbhári H. S. extended over a week, as after the observations to Pil H. S., Mr. Prunty had to return to Agoada S., but before he reached it, the haze, combined with the smoke from the burning of the jungle, made the atmosphere almost impenetrable for observing; however by dint of patience and perseverance the observations on the ray Kumbhári-Agoada, over 41 miles in length, were completed on the 24th April, and these brought the revision of heights of the South Konkan Series to a successful close.

"The work progressed very favourably till the 18th February, after which the observations were very much retarded by hazy weather, which shut out the signals for days together and caused Mr. Prunty and myself very great anxiety.

"The traffic along the *ghát* roads leading into the Konkan from the Deccan is enormous, especially on the Kumbhárli *ghát* road to Chiplún—a large town in the Ratnagiri Collectorate. While I was marching on this road, hundreds of carts, laden with molasses, grain, earth-nuts, cotton, &c., were met daily, and on enquiry at some of the toll-houses I learned that in the cold weather as many as 600 carts are registered daily on their way to Chiplún, and from 200 to 300 more on their return from Chiplún to the Deccan country.

"The health of the party throughout the season was excellent, not a single man having been ill."

"I have to acknowledge the very great assistance I received from the native officials of the Poona and Satára districts; from those of the Native States of Bhor, Kolhapur and Sávantvadi, and from the Portuguese Government at Goa, while carrying on the revision of heights of the South Konkan Series."

The extracts which follow have been taken from a report on his work submitted by Mr. Prunty :—

"On the 24th November I visited Karanja H. S. which is situated on the highest part of the hill of that name, and as this hill rises nearly 1,000 feet immediately above the coast line, it proved a pretty stiff ascent—the way up consists of the remains of a series of steps constructed by the Portuguese many years

ago, when this part of India belonged to them. On the 25th November the theodolite and tents reached the top of the hill, and by the 29th observations to Mandwi H. S. and Titvi H. S. were completed.

"While encamped on the top of Karanja, on the night of the 27th November, I was disturbed from my sleep by the agonized howling of a small fox-terrier tied to the foot of my bed. I got up to ascertain the cause of the disturbance, but I had no sooner alighted on the ground than I felt my feet stung by a myriad of large black hairy ants, causing intense pain and great irritation. I found out next morning that these invaders were a detachment from a colony of ants that had passed over the hill a short distance from where my camp was pitched.

"On the 3rd December I reached Murúd on my way to Titvi H. S., and was detained there for two days. The town was in mourning for the Nawab of Janjira's wife, and out of respect for the deceased lady all business was suspended until the 5th December, when I managed to procure sufficient coolies for the carriage of the instrument and camp equipment to Titvi H. S., situated on a range of hills 7 miles inland. The march occupied the greater part of the day as the circuitous track was over hilly and undulating country covered with dense scrub jungle.

"While at Ghirya, the haze for the first time during the season presented a formidable barrier to the progress of the observations, and for several days shut out the luminous signals on the diagonal rays effectually. I have never encountered such dense haze in other parts of India as I experienced this season, towards the end of February and the early part of March. At Parule H. S., too, the haze was very similar to what I had met with at Ghirya H. S., and caused great delay in the observations taken there: in fact, I may say until the close of the season's work on the 22nd April, the haze was a constant attendant on the observations, and it was with the greatest difficulty that the last ray, Agoada-Kumbhári, was observed.

"The most expeditious way of getting from station to station on the western flank of the Series was by country boats, and I adopted this mode of transit, though fraught with great inconvenience and no little danger in a rough sea. On several occasions, while travelling in this way, the boats threatened to capsize, and when going to Parule H. S. towards the end of the season, we escaped being wrecked by the merest chance.

"The health of the party, on the whole, was very fair. Towards the end of March three-fourths of the men were attacked by itch of a virulent type, and some cases were so bad as to present the appearance of scurvy. After it had been stamped out, three of the men were laid up with guinea-worm, and for a time were entirely unfit for any work."

"The aspect of the coast line from Karanja to Goa, as it stretches along the blue sea, presents the appearance of low ranges of rugged hills folded inextricably together, with stretches of grey sand beach on which the foam of the sea lightly touches, streaking it like marble, but the stretches of sand are comparatively few and hardly disturb the continuity of the rock-bound coast. As one sails along, there is scarcely a sign of life perceptible. Here and there an island fortress a short distance from the coast, attracts attention.

"The trade carried on by native craft is very brisk, and the wealth of the people on the sea-board is essentially derived from maritime pursuits."

REDUCTION OF THE TIDAL OBSERVATIONS AND COMPUTATIONS CARRIED ON IN THE HEAD-QUARTERS OFFICE, POONA.

A very large amount of work in connection with the tidal calculations has been done in the Poona office during the past year. The observations at 13 ports have been reduced, and the tabulated values of the tidal constants at these stations, together with the usual discussion of the results will be found appended to this report. Although less by one than the number discussed in the preceding Annual Report, the labour of the reductions has been greater than what was then described. This is due to the breaks in the tidal registrations which occurred at various stations. When the registrations at a tidal station are broken, modifications are necessary in the calculations of the summation and means of all the 20 series of short period tides, and the 5 long period tides have in the first instance to be fully calculated out approximately, ignoring the breaks, and the results so obtained are treated according to Professor Darwin's method, in order to arrive at the most probable values to interpolate on the days when the breaks occurred. Having filled up the blanks in this manner, the long period tides have to be calculated afresh in order to obtain the final values.

The present state of the ordinary tidal computations is shown in the following table, together with their state at the end of October 1885, extracted from the Annual Report for 1884-85. The actual amount of work done in the period embraced by the table, which in the present instance is only eleven months, can thus be easily seen. The extra tidal work is not entered in it. This consisted in preparing tracings of five months' tidal diagrams of the Kidderpore observatory, which were sent last April to the Calcutta Port Commissioners according to their request. All the work also connected with the tide tables will be separately mentioned.

State of the ordinary reductions of the yearly tidal registrations at the beginning and end of the survey year 1885-86.

Observatory at work during the year.	State at end of October 1885.	State at end of September 1886.
ADEN	1884-85. Summation of series ready .	1884-85. Calculations completed. 1885-86. Diagrams not read off.
KURRACHEE . . .	1884-85 Additions of hourly heights of each series ready.	1884-85. Calculations completed. 1885-86. Diagrams completed and all read off, and the hourly readings being copied from the S series into the other series.
BHAVNAGAR . . .	. . . . .	Newly started observatory. No diagrams read off yet.

State of the ordinary reductions of the yearly tidal registrations, &c.—contd.

Observatory at work during the year.	State at end of October 1885.	State at end of September 1886.
Bombay	1885. Year incomplete, so the readings from the diagrams are not read off.	1885. Diagrams completed, and all read off, and computations completed.
Mormugáo	1885-86. Year incomplete, so the readings from the diagrams are not read off.	1885-86. Diagrams completed, and all read off, and computations completed.
Cochin	. . . . .	Newly started observatory. No diagrams read off yet.
Colombo	1885-86. Year incomplete, so the readings from the diagrams are not read off.	1885-86. Diagrams completed, and all read off, and summations of series ready.
Galle	1885-86. Year incomplete, so the readings from the diagrams are not read off.	1885-86. Diagrams completed, and all read off, and summations of series ready.
Negápatam	1885-86. Year incomplete, so the readings from the diagrams are not read off.	1885-86. Diagrams not yet read off.
Madras	1884-85. Additions of hourly heights of each series in hand.	1884-85. Calculations completed. 1885-86. Diagrams not yet read off.
Cocanada	. . . . .	Newly started observatory. No diagrams read off yet.
Vizagapatam (closed March 1885).	1884-85. Additions of hourly heights of each series in hand.	1884-85. Calculations completed.
False Point (closed September 1885).	1884-85. Additions of hourly heights of each series in hand.	1884-85. Calculations completed.
Dublat	1884-85. The hourly readings being copied from the S series into the other series.	1884-85. Calculations completed. 1885-86. Diagrams not yet read off.
Diamond Harbour (closed April 1886).	1884-85. The hourly readings being copied from the S series into the other series.	1884-85. Additions of hourly heights of each series ready. 1885-86. Diagrams not yet read off.
Kidderpore	1884-85. The hourly readings being copied from the S series into the other series.	1884-85. Calculations completed. 1885-86. Diagrams completed, and all read off, and the hourly readings copied from the S series into the other series.
Chittagong	. . . . .	Newly started observatory. No diagrams read off yet.
Elephant Point	1884. Summations of series ready.	1884. Calculations completed. 1885. Diagrams completed, and all read off, and the hourly readings from the diagrams in hand.
Rangoon	1884-85. The hourly readings being copied from the S series into the other series.	1884-85. Calculations completed. 1885-86. Diagrams completed, and all read off, and calculations as far as the end of additions of the hourly heights of each series ready.
Amherst	1884-85. Diagrams ready; but the hourly readings not yet completed.	1884-85. Readings of diagrams completed, and the additions of the hourly heights of each series ready. 1885-86. Diagrams not yet read off.
Moulmein (closed April 1886).	1884-85. Diagrams ready; but the hourly readings not yet complete.	1884-85. Readings of diagrams and computations completed. 1885-86. Diagrams not yet read off.
Port Blair	1884-85. Diagrams ready; but the hourly readings not yet complete.	1884-85. Readings of diagrams and computations completed. 1885-86. Diagrams not yet read off.

The Tide Tables.

In addition to the tidal calculations reported on above, the usual amount of work was done in connection with the issue of the Tide Tables which will contain the predicted heights and times of every high and low water during the year 1887 and January 1888, for twenty-three ports. As was done last year, the values of the constants have been sent to Mr. Roberts in London ready for use. The mode of calculating them was described in the Annual Report for 1884-85, and need not be repeated here; and the method employed for

the riverain tides will be found described in the Tide Tables in the prefaces to the several riverain ports. In connection with these riverain tides, and in addition to the data furnished in previous years, the daily values of the actual and predicted heights and times of high and low water at Kidderpore, Dublat, Rangoon and Moulmein were sent every month to Mr. Roberts, together with similar data for the whole of the year 1885 at Elephant Point, according to an arrangement made by Major Baird.

An important improvement has been introduced into the Tide Tables for 1887 by the employment of a scientific datum which has at last rendered it possible to fix finally the datum for each of the tidal observatories. The following extract from Major Baird's preface to the Tide Tables for 1887 describes the new datum, which has been termed "The Indian Spring low water mark:—"

"The datum line for soundings adopted by the Admiralty is the 'mean low water of ordinary spring tides.' This term does not appear to have a scientifically accurate meaning with reference to tidal theory, but the datum line is usually determined by taking the mean of such spring tide observations as are available.

"It is desirable that a datum line should possess the following qualifications:—(1) it should be rigorously determinable from tidal theory, when complete observations are at hand; (2) it should be sufficiently low to preclude the occurrence of a large depression of the water, at any spring low water, below the datum even at ports where there is a considerable diurnal inequality; (3) it should, for rough navigational purposes, be practically the same as the Admiralty datum.

"After discussion with Professor Darwin and Captain Wharton, R. N., the Hydrographer to Her Majesty's Admiralty, it has been agreed to adopt a datum line to be called "The Indian Spring low water mark." This datum is defined as the sum of the semi-ranges of the principal lunar (M_2) and principal solar (S_2) semi-diurnal tides, and of the uni-solar diurnal (K_1) and the lunar diurnal (O_1) tides below mean sea-level, that is to say A_0—[H of M_2 + H of S_2 + H of K_1 + H of O_1] above the zero of the gauge."

At some ports the old datum has been retained as differing very slightly from "the Indian Spring low water mark." At others, including the riverain ports, local considerations have forbidden the adoption of the new datum. The following table has been prepared to show the datum finally adopted at each of the tidal observatories.

Final Datum for each of the Survey of India Tidal Observatories.

Name of Tidal Observatory.	Datum to which the heights in the Tide Tables for 1887 are referred.	Datum below Mean Sea-level.
		Feet.
Aden	Mean low water ordinary spring tides	4·226
Kurrachee	Kurrachee Harbour Works Datum	5·183
Okha	Indian Spring Low Water Mark	7·149
Kathiwadar (or Shiyalbet)†	Do. do. do.	6·508
Bombay	Mean of the lowest Ordinary Spring Tides, *viz.*, 72 feet above the "Town Hall Datum"	8·223
Mormugáo	Mormugáo Harbour Works Datum, or the same level as low water ordinary springs	3·512
Karwar	Indian spring low water mark	3·867
Beypore	Do. do. do.	2·328
Pamban	Do. do. do.	1·366
Galle	Do. do. do.	1·092
Colombó	Do. do. do.	1·238
Negapatam	Do. do. do.	1·310
Madras	Do. do. do.	1·874
Vizagapatam	Do. do. do.	2·623
False Point	Lowest low water recorded by the self-registering tide gauge between 1880-85	5·081
Dublat	Level of the zero of the Kedgeree gauge—Datum for River Survey Charts of Saugor Island	9·608
Diamond Harbour	Level of Sill of Kidderpore Dock	*8·995
Kidderpore	Do. do. do.	*10·686
Elephant Point	Datum to be adopted by River Surveyor, corresponding very nearly to the lowest recorded low water and 24 feet exactly below B. M. A. at the observatory	*7·686
Rangoon	Zero of the graduated staff at Brooking Street Wharf—Datum used by the River Surveyor	*10·641
Amherst	Mean low water ordinary spring tides	9·145
Moulmein	2 feet 8 inches lower than the mean low water ordinary Spring Tides	*7·667
Port Blair	Indian Spring low water mark	3·546

* Note.—These are reckoned from Mean River Level—not Sea Level.
† " This is not an observatory of the Survey Department, but appertains to the Bhavnagar State.

No. 1.

Statement showing the Percentage and the amount of the Errors in the Predicted Times of High Water at the various Tidal Stations for the year 1885.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	705	80	20	...	...	...
Kurrachee	705	43	39	8	7	3
Bombay	705	42	42	11	5	1
Negapatam	614	22	37	14	17	10
Madras	705	17	16	13	29	25
False Point	469	29	37	14	11	9
Dublat	705	25	40	15	15	5
Diamond Harbour	705	30	35	13	16	6
Kidderpore	706	24	37	12	18	9
Elephant Point	705	15	32	10	20	23
Rangoon	692	22	37	14	18	9
Amherst	664	52	21	10	9	8
Moulmein	705	20	37	14	19	10
Port Blair	692	32	37	10	9	12

No. 2.

Errors in the Predicted Times of Low Water.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	706	81	19	...	...	...
Kurrachee	707	37	40	11	9	3
Bombay	705	38	40	9	9	4
Negapatam	614	17	28	9	21	25
Madras	705	21	18	11	26	24
False Point	470	31	36	13	12	8
Dublat	705	23	35	12	20	10
Diamond Harbour	705	21	31	15	21	12
Kidderpore	705	22	35	15	18	10
Elephant Point	703	9	14	7	13	57
Rangoon	691	21	33	13	20	13
Amherst	663	37	21	12	16	14
Moulmein	705	30	41	14	9	6
Port Blair	690	27	36	12	10	15

No. 3.

Statement showing the Percentage and the amount of the Errors in the Predicted Heights of High Water at the various Tidal Stations for the year 1885.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	705	92	8	...	...
Kurrachee	705	82	15	2	1
Bombay	705	67	25	7	1
Negapatam	614	31	44	16	9
Madras	705	63	32	3	2
False Point	469	55	38	7	...
Dublat	705	57	29	10	4
Diamond Harbour	705	42	26	16	16
Kidderpore	706	27	25	19	29
Elephant Point	705	1	1	1	97
Rangoon	692	50	29	12	9
Amherst	664	37	29	18	16
Moulmein	705	41	25	15	19
Port Blair	692	89	11	...	...

No. 4.

Errors in the Predicted Heights of Low Water.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	706	88	12	...	...
Kurrachee	707	75	20	4	1
Bombay	705	66	28	5	1
Negapatam	614	21	49	22	8
Madras	705	85	14	1	...
False Point	470	64	27	8	1
Dublat	705	56	24	12	8
Diamond Harbour	705	47	33	13	7
Kidderpore	705	34	24	13	29
Elephant Point	705	10	9	9	72
Rangoon	691	27	26	26	21
Amherst	665	11	10	12	67
Moulmein	705	34	31	17	18
Port Blair	690	81	14	3	2

VALUES OF THE TIDAL CONSTANTS, ADEN, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

$A_0 = 5{\cdot}849$ feet.

S_1	H = R =	0°·074	M_6	R =	0°·005	Q_1	R =	0°·017	T_2	R =	0°·081
	κ = ζ =	173°·69		ζ =	42°·44		ζ =	79°·25		ζ =	335°·74
S_2	H = R =	0°·700		H =	0°·005		H =	0°·144		H =	0°·081
	κ = ζ =	244°·76		κ =	317°·12		κ =	29°·14		κ =	275°·15
S_4	H = R =	0°·004	M_8	R =	0°·002	L_2	R =	0°·055	$(MS)_4$	R =	0°·014
	κ = ζ =	6°·95		ζ =	318°·01		ζ =	190°·36		ζ =	279°·81
S_6	H = R =	0°·006		H =	0°·001		H =	0°·047		H =	0°·014
	κ = ζ =	188°·43		κ =	84°·26		κ =	223°·65		κ =	131°·37
S_8	H = R =	0°·001	O_1	R =	0°·546	N_2	R =	0°·449	$(2SM)_2$	R =	0°·021
	κ = ζ =	265°·60		ζ =	81°·39		ζ =	11°·29		ζ =	319°·25
				H =	0°·670		H =	0°·434		H =	0°·021
				κ =	37°·04		κ =	217°·09		κ =	107°·69
M_1	R =	0°·075	K_1	R =	1°·156	λ_2	R =	0°·038	$2N_2$	R =	0°·111
	ζ =	138°·15		ζ =	139°·92		ζ =	83°·93		ζ =	336°·71
	H =	0°·004		H =	1°·303		H =	0°·037		H =	0°·107
	κ =	35°·62		κ =	34°·24		κ =	258°·74		κ =	176°·75
M_2	R =	1·639	K_2	R =	0°·156	ν_2	R =	0°·161	$(M_2N)_4$	R =	0°·038
	ζ =	13°·42		ζ =	265°·42		ζ =	145°·42		ζ =	277°·38
	H =	1·581		H =	0°·206		H =	0°·156		H =	0°·036
	κ =	224°·98		κ =	233°·53		κ =	213°·74		κ =	334°·74
M_3	R =	0°·015	P_1	R =	0°·399	μ_2	R =	0°·089	$(M_2K_1)_3$	R =	0°·031
	ζ =	74°·78		ζ =	283°·29		ζ =	129°·78		ζ =	297°·26
	H =	0°·014		H =	0°·399		H =	0°·083		H =	0°·033
	κ =	212°·12		κ =	31°·75		κ =	192°·91		κ =	43°·14
M_4	R =	0°·003	J_1	R =	0°·083	R_2	R =	0°·019	$(2M_2K_1)_3$	R =	0°·006
	ζ =	262°·65		ζ =	155°·64		ζ =	1°·85		ζ =	113°·46
	H =	0°·003		H =	0°·099		H =	0°·019		H =	0°·006
	κ =			κ =	57°·30		κ =	242°·44		κ =	282°·26

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·044	47°·57	0·039	53°·33
„ Fortnightly „	0·008	275·50	0·012	35·75
Luni-Solar „	0·020	116·43	0·019	264·87
Solar-Annual „	0·367	14·51	0·367	356·05
„ Semi-Annual „	0·102	195·66	0·102	158·75

The value of (A_0) the mean level of the sea for 1884-85 is 5·849 feet above the zero of the gauge, and is the highest yet obtained; last year it was 5·800 feet.

The mean amplitude (H) of the main lunar tide (M_2) is 1·581 feet; it is almost identical with the value obtained last year, *viz.*, 1·588, which is the highest value obtained at Aden. The epoch of this tide is 224°·98 and corresponds very closely to that of the previous year.

The main solar tide (S_2) has an amplitude of 0·700 feet and agrees well with the values obtained in previous years; its epoch, too, is about identical with that of the past year.

The main diurnal tide (K_1) has a mean amplitude of 1·303 feet, which is almost exactly the mean of the values obtained in the previous five years. Its epoch is 34°·24 and is the smallest value yet obtained.

The proportion of the main solar tide (S_2) to the main lunar tide (M_2) is again 44 per cent.; theoretically it should be 47 per cent.

The principal diurnal tide (K_1) is 82 per cent. of the main tide, somewhat lower than the proportion obtained last year, *viz.*, 83 per cent.; theoretically it should be 58 per cent., but at Aden this tide has always been found to be very large.

The proportion of the smaller lunar elliptic tide (L_2) is this year 0·030, and accords well with the theoretical value 0·028; the larger elliptic tide (N_2) is 0·275 of the main tide, which is slightly larger than the proportion obtained last year, 0·266, and approaches the values of 1879-80 and 1880-81; the theoretical proportion being 0·194.

The smaller evectional tide (λ_2) is this year 0·023 of the main tide, and approaches the 1881-82 proportion, the largest yet obtained; theoretically it should be 0·007, last year it was 0·009 of the main tide.

The larger evectional tide (ν_2) has a proportion of 0·099, which is identical with the value obtained in 1879-80 and is nearly three times the theoretical proportion 0·038.

With regard to the diurnal tides the proportions to the main tide are as follow:—

		Aden, 1884-85.	Theoretical.
Luni-Solar	K_1	0·824	0·584
Lunar	M_1	·053	·036
Solar Declinational	P_1	·252	·193
Lunar „	O_1	·424	·415
Lunar Elliptic	J_1	·063	·033
Solar „	Q_1	·091	·080

From which it will be seen that the largest component (K_1) is nearly half as large again as its theoretical value; that the next larger component (O_1) agrees well with the theoretical proportion; and that the remaining diurnal tides are from 1 to 6 per cent. greater than the theoretical value—a result which accords well with the proportions hitherto obtained; the value of (M_1) however is the largest yet obtained at this port.

As usual at this port, the overtides are all quite insignificant, with the exception of the ter-diurnal lunar tide (M_3), which, though barely appreciable, seems clearly to exist, as year by year this overtide is found to have an amplitude of 0·01 of the main tide, a value which agrees with theory: its epoch, as determined from six years' observations is about 209°.

The compound tides $(M_2K_1)_3$, $(MS)_4$, $(2\,M_2K_1)_3$, $(M_2\,N)_4$, $(2SM)_2$ are as usual very small, and are almost identical with last year's values.

Of the long period tides, the solar annual has the greatest amplitude, and is again this year 23 per cent. of the main tide; its time of maximum is 10 days later than was obtained last year, *viz.*, the 17th March.

The solar semi-annual tide is again 7 per cent. of the main tide, and its epoch continues to be variable.

The lunar monthly tide is 0·025 of the main tide, and just about half the theoretical value, 0·046.

The luni-solar fortnightly tide is 0·012 of the main tide, and this is the largest value yet obtained of this tide: theoretically it is 0·007 of the main tide.

The lunar fortnightly tide has this year the smallest proportion to the main tide that has yet been obtained, *viz.*, 0·008 of the main tide: theoretically it should be 0·086 of the main tide: the mean of the last five years is 0·031.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0 = 7·198 feet.

S_1	H = R =	0·055	M_6	R =	0·050	Q_1	R =	0·090	T_2	R =	0·126
	κ = ζ =	182°·90		ζ =	282°·74		ζ =	200°·29		ζ =	80°·00
S_2	H = R =	0·963		H =	0·045		H =	0·111		H =	0·126
	κ = ζ =	323°·13		κ =	206°·00		κ =	45°·76		κ =	321°·33
S_4	H = R =	0·011	M_8	R =	0·002	L_2	R =	0·089	$(MS)_4$	R =	0·026
	κ = ζ =	44°·23		ζ =	183°·81		ζ =	227°·80		ζ =	124°·84
S_6	H = R =	0·005		H =	0·001		H =	0·076		H =	0·025
	κ = ζ =	323°·57		κ =	321°·50		κ =	315°·51		κ =	339°·26
S_8	H = R =	0·001	O_1	R =	0·541	N_2	R =	0·618	$(2SM)_2$	R =	0·018
	κ = ζ =	240°·26		ζ =	146°·02		ζ =	116°·64		ζ =	327°·65
				H =	0·666		H =	0·596		H =	0·017
				κ =	47°·29		κ =	275°·26		κ =	113°·23
M_1	R =	0·036	K_1	R =	1·151	λ_2	R =	0·067	$2N_2$	R =	0·087
	ζ =	202°·37		ζ =	94°·08		ζ =	165°·65		ζ =	128°·62
	H =	0·042		H =	1·300		H =	0·065		H =	0·084
	κ =	111°·46		κ =	45°·87		κ =	290°·31		κ =	231°·44
M_2	R =	2·640	K_2	R =	0·232	ν_2	R =	0·185	$(M_2N)_4$	R =	0·072
	ζ =	79°·60		ζ =	232°·97		ζ =	195°·95		ζ =	28°·54
	H =	2·546		H =	0·308		H =	0·179		H =	0·067
	κ =	294°·02		κ =	316°·14		κ =	320°·14		κ =	41°·59
M_3	R =	0·029	P_1	R =	0·395	μ_2	R =	0·044	$(M_2K_1)_3$	R =	0·019
	ζ =	207°·30		ζ =	356°·07		ζ =	218°·85		ζ =	347°·51
	H =	0·027		H =	0·395		H =	0·041		H =	0·020
	κ =	348°·93		κ =	46°·43		κ =	287°·69		κ =	153°·72
M_4	R =	0·031	J_1	R =	0·059	R_2	R =	0·019	$(2M_2K_1)_3$	R =	0·022
	ζ =	311°·71		ζ =	71°·23		ζ =	12°·83		ζ =	249°·67
	H =	0·029		H =	0·071		H =	0·019		H =	0·023
	κ =	20°·56		κ =	80°·19		κ =	311°·51		κ =	6°·72

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·031	63°·08	0·027	118°·88
„ Fortnightly „	0·037	161·93	0·058	33·82
Luni-Solar „ „	0·038	51·29	0·037	196·87
Solar-Annual „	0·139	4·18	0·139	43·81
„ Semi-Annual „	0·137	81·28	0·137	160·55

The mean level of the sea (A_0) is 7·198 feet above the zero of the gauge, and very slightly higher than last year's value, 7,192.

The main lunar tide (M_2) has a mean amplitude of 2·546 and is 0·02 foot less than the value obtained last year: its epoch is almost identical with the values obtained for the previous 4 years.

The main solar tide (S_2) has an amplitude of 0·963 foot, or just 0·01 foot more than it was last year, and almost identical with the value obtained in 1880-81, 1881-82, and 1882-83: its epoch too compares very well with those of the previous six years.

The main solar tide (S_2) is 0·378 of the main tide—a proportion which accords well with those of former years: its theoretical proportion is 0·465.

The luni-solar semi-diurnal tide (K_2) has again this year a proportion nearly equal to the theoretical.

The two lunar elliptic tides (N_2 and L_2) are respectively 23 and 3 per cent. of the main tide; these proportions are similar to what generally obtained at Kurrachee: the theoretical proportions of these tides are 19 and 3 per cent.

The larger evectional tide (ν_2) is this year nearly double the theoretical proportion, being 0·07, while the theoretical is 0·038; last year it was only 0·01, but that was the lowest value obtained at Kurrachee.

The smaller evectional tide (λ_2) is this year 0·026 of the main tide; this is the largest value obtained since 1878-79, and is about four times the theoretical value, which is 0·007.

The lunar elliptic tide of the second order ($2N_2$) is 0·033 of the main tide; last year it was 0·043: the theoretical proportion is 0·026.

The variational tide (μ_2) has a proportion of 0·016 to the main tide, a value very similar to what was obtained in 1882-83, *viz.*, 0·015: the theoretical proportion is 0·024. Since 1878-79 it is noticeable that the proportions are alternately about 0·016 and 0·03..

The solar elliptic semi-diurnal tides (T_2 and R_2), which are only evaluated every alternate year, were calculated: the former is found to be 5 per cent. of the main tide and nearly double the theoretical proportion, and the latter is insignificant as usual.

The principal diurnal tide (K_1) is as usual 51 per cent. of the main tide, while the theoretical proportion is 58 per cent.

The lunar declinational tide (O_1) and the solar declinational tide (P_1) are respectively 26 and 16 per cent. of the main tide, and accord well with the previous values: the theoretical proportions of these tides are respectively 42 and 19 per cent. of the main tide.

The remaining diurnal tides (Q_1, J_1, M_1) are 4, 3 and 2 per cent. of the main tide; theoretically they should be 8, 3 and 4 per cent. So that (Q_1) and (M_1) are each half of what they should be; and (J_1) is identical with the theoretical value. (S_1) is slightly lower in its proportion to the main tide than it was last year; but there is no theoretical value to compare it with.

The overtides (M_3), (M_4), and (M_6) are respectively 1, 1, and 2 per cent. of the main tide; and these proportions are generally obtained. Of the remaining overtides (S_4), (S_6) are insignificant; and (M_8) and (S_8) have altogether vanished this year.

The compound tides are all insignificant, the greatest being $(M_2 N)_4$.

The lunar monthly and lunar fortnightly tides agree in their proportions to the main tide with the values obtained last year; they are both less than the theoretical proportions, but this is usually the case at Kurrachee.

The luni-solar fortnightly tide is this year 0·015 of the main tide and double the theoretical value.

The solar annual tide is 0·055 of the main tide, and just 2 per cent. more than it was found to be last year.

The solar semi-annual tide is 0·054 of the main tide, or about one per cent. more than the theoretical value and 2 per cent. less than last year.

With regard to the epochs of the luni-solar fortnightly, the lunar monthly and the lunar fortnightly, they are all as usual very divergent. The epoch of the solar annual is 44°, or about 5° later than last year; and that of the solar semi-annual is 160°, or 10° earlier than last year.

VALUES OF THE TIDAL CONSTANTS, BOMBAY, 1885.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885 observations at Bombay; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885 observations:—

Short Period Tides.

$A_0 = 10{\cdot}304$ feet.

S_1	H = R =	0·053	M_6	R =	0·011	Q_1	R =	0·106	T_2	R =	0·237
	κ = ζ =	168°·44		ζ =	93°·01		ζ =	242°·35		ζ =	349°·63
S_2	H = R =	1·627		H =	0·010		H =	0·132		H =	0·237
	κ = ζ =	2°·87		κ =	95°·67		κ =	35°·75		κ =	349°·50
S_4	H = R =	0·010	M_8	R =	0·008	L_2	R =	0·047	$(MS)_4$	R =	0·140
	κ = ζ =	325°·31		ζ =	20°·27		ζ =	103°·83		ζ =	20°·13
S_6	H = R =	0·003		H =	0·007		H =	0·041		H =	0·135
	κ — ζ =	184°·09		κ =	23°·81		κ =	305°·05		κ =	21°·01
S_8	H — R =	0·002	O_1	R =	0·549	N_2	R =	1·033	$(2SM)_2$	R =	0·047
	κ — ζ =	105°·52		ζ =	237°·97		ζ =	328°·12		ζ =	100°·85
				H =	0·682		H =	0·995		H =	0·046
				κ =	47°·88		κ =	312°·50		κ =	99°·97
M_1	R =	0·044	K_1	R =	1·232	λ_2	R =	0·004	$2N_2$	R =	0·159
	ζ =	221°·23		ζ =	214°·49		ζ =	291°·80		ζ =	278°·06
	H =	0·050		H =	1·398		H =	0·004		H =	0·153
	κ =	69°·17		κ =	45°·58		κ =	95°·28		κ =	245°·94
M_2	R =	4·226	K_2	R =	0·311	ν_2	R =	0·054	$(M_2N)_4$	R =	0·140
	ζ =	328°·94		ζ =	144°·20		ζ =	354°·62		ζ =	252°·19
	H =	4·072		H =	0·415		H =	0·052		H =	0·130
	κ =	329°·83		κ =	346°·37		κ =	12°·92		κ =	237°·45
M_3	R =	0·084	P_1	R =	0·415	μ_2	R =	0·194	$(M_2K_1)_3$	R =	0·094
	ζ =	212°·93		ζ =	234°·34		ζ =	293°·61		ζ =	298°·61
	H =	0·079		H =	0·415		H =	0·180		H =	0·103
	κ =	34°·26		κ =	43°·24		κ =	295°·38		κ =	130°·58
M_4	R =	0·130	J_1	R =	0·082	R_2	R =	0·029	$(2M_2K_1)_3$	R =	0·061
	ζ =	325°·63		ζ =	238°·57		ζ =	46°·68		ζ =	240°·17
	H =	0·121		H =	0·099		H =	0·029		H =	0·065
	κ =	327°·40		κ =	86°·05		κ =	226°·82		κ =	50°·86

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·029	47°·08	0·026	63°·58
„ Fortnightly „	0·052	208·27	0·083	49·34
Luni-Solar „ „	0·054	268·93	0·052	268·04
Solar-Annual „	0·042	177·75	0·042	98·85
„ Semi-Annual „	0·042	18·95	0·042	221·16

The value of (A_0) the mean level of the sea at Bombay is this year 10·304 feet above the zero of the gauge; it is the largest value yet obtained, being 0·047 foot higher than the mean of the two preceding years, and nearly $\frac{5}{100}$ths of a foot above the mean of the seven previous years' observations at this station.

The mean amplitude (H) of the main lunar tide (M_2) is almost identical with the value obtained last year: it is 4·072 feet, while last year it was 4·071 feet. The epoch of this tide is this year 1½ degrees more than last year's value; but the greatest discrepancy between the epochs of this tide for any two years does not exceed 2°·28, or less than 5 minutes in time.

The amplitude of the main solar tide (S_2) is identical with the value obtained in 1880 *viz.*, 1·627 feet; and is only 0·003 foot less than the mean of the whole eight years' observations. The epoch (κ) of this tide is 2°·87; last year it was 1°·48, but that was an exceptionally low value; and the value now obtained agrees very well with the mean (2°·81) of the several years' observations.

The proportion of the main solar tide to the main lunar tide is 0·400, and is very accordant with the mean proportion from the several years' values, *viz.*, 0·402; theoretically it should be 0·465 of the main tide.

The luni-solar semi-diurnal tide (K_2) is this year 10 per cent. of the main tide, which proportion is generally obtained: theoretically it should be 13 per cent. The epoch of this tide is 346° and is the lowest yet obtained, but does not differ by more than 5° or 10 minutes in time from the mean of all the values of the epoch at this place.

The proportion of the larger component (N_2) of the lunar elliptic semi-diurnal tides is 0·244 of the main tide, which is identical with the 1880 proportion, and very accordant with the other years' values, which have been from 5 to 6 per cent. greater than the theoretical value.

The epoch is 312°·5 and agrees very well with the three preceding years' values; and the greatest difference between any two years' values does not exceed 4° or 8 minutes in time.

The smaller component (L_2) of the lunar elliptic semi-diurnal tides is this year only 1 per cent. of the main tide; in 1883 it was also 1 per cent.; but the value of this tide varies between 1 and 3 per cent. and in 1882 it was very nearly 4 per cent. of the main tide.

With regard to the evectional semi-diurnal tides, the larger component (ν_2) has a proportion of 0·013 of the main tide, the smallest proportion yet obtained: theoretically it should be 4 per cent. The smaller component (λ_2) is as usual quite insignificant.

The lunar elliptic tide of the second order ($2N_2$) bears very nearly the same proportion to the main tide as it did last year, and is about 1 per cent. greater than the theoretical value, 0·025.

The solar elliptic semi-diurnal tides (T_2 and R_2), which are only evaluated every alternate year, are respectively 0·058 and 0·007 of the main tide; the former is a little more than double the theoretical value and agrees with the proportion obtained in 1881; and the latter agrees with all the previous values.

The variational tide (μ_2) is 0·044 of the main tide,—a value nearly twice as great as theory gives; but this proportion has always been obtained for this tide at Bombay.

The diurnal tides are all smaller in their proportion to the main tide than the theoretical values; but the values are very accordant with those usually obtained, and the following table shows the proportions of the principal diurnal tides to the main tide for the year 1885, compared with the theoretical values:—

	Bombay, 1885.	Theoretical.
Luni-solar (K_1)	0·343	0·584
Lunar declinational (O_1)	·167	·415
Solar „ (P_1)	·102	·193
Solar elliptic (Q_1)	·032	·080
Lunar „ (J_1)	·024	·033
Lunar diurnal (M_1)	·012	·036

The epochs of the first three (K_1, O_1, and P_1) agree very well with those previously obtained, in fact they are very accordant year after year; but those of the other three tides vary as follow:—(Q_1) from 36° to 60°, (J_1) from 40° to 89°, and (M_1) from 19° to 105.

The proportions of the overtides of (S) and (M) are all nearly identical with the values found in former years.

With regard to the compound tides, $(M_2\ K_1)_3$ is this year 2½ per cent. of the main tide, while in the two previous years it was under 1 per cent.; theoretically it should be 12 per cent.; $(M\ S)_4$, $(2M_2K_1)_3$, and $(2\ S\ M)_2$ agree with the proportions hitherto obtained; and $(M_2\ N)_4$ is 3 per cent. of the main tide; last year it was 2 per cent. and theoretically it should be 4 per cent.

Of the long period tides, the lunar monthly and the luni-solar fortnightly agree with the proportions obtained last year, and are each 1 per cent. of the main tide: the latter is very nearly the theoretical proportion, but the former is about 3 per cent. less than it should be, and this is generally found to be the case.

The lunar fortnightly tide has this year a proportion of 0·020 of the main tide, the largest yet obtained, but does not differ much from the value, 0·017 obtained in 1878; theoretically it should be 0·086 of the main tide.

The solar annual tide is 0·010 of the main tide; the proportions of this tide are very divergent, the smallest being 0·008 and the largest 0·064 of the main tide. The epoch of this tide is for this year 98°, which is 18° less than the value obtained in 1878; between these two years, however, the values were very different and varied between 285° and 355°.

The solar semi-annual tide has this year a proportion of 0·010 of the main tide, the lowest yet obtained; theoretically it should be 4 per cent. The epoch is 221°, or about 12° more than last year and very accordant with those of 1879 and 1882; the times of maxima remaining between the 11th June and 16th July, and the 11th December and 16th January.

VALUES OF THE TIDAL CONSTANTS, MORMUGAO, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 observations at Mormugão; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

A_0=5·577 feet.

S_1	H=	0·041	M_6	R=	0·014	Q_1	R=	0·096	T_2	R=	0·068
	κ=ζ=	177°·47		ζ=	255°·32		ζ=	221°·06		ζ=	350°·89
S_2	H=R=	0·641		H=	0·013		H=	0·119		H=	0·068
	κ=ζ=	332°·23		κ=	245°·04		κ=	51°·56		κ=	277°·82
S_4	H=R=	0·009	M_8	R=	0·012	L_2	R=	0·060	$(MS)_4$	R=	0·029
	κ=ζ=	99°·97		ζ=	33°·69		ζ=	252°·81		ζ=	70°·65
S_6	H=R=	0·005		H=	0·011		H=	0·053		H=	0·028
	κ=ζ=	109°·89		κ=	19°·98		κ=	338°·19		κ=	67°·22
S_8	H=R=	0·004	O_1	R=	0·423	N_2	R=	0·455	$(2SM)_2$	R=	0·003
	κ=ζ=	24°·44		ζ=	315°·81		ζ=	188°·93		ζ=	135°·00
				H=	0·524		H=	0·438		H=	0·003
				κ=	49°·59		κ=	282°·22		κ=	138°·43
M_1	R=	0·053	K_1	R=	0·911	λ_2	R=	0·015	$2N_2$	R=	0·072
	ζ=	61°·09		ζ=	142°·07		ζ=	185°·95		ζ=	73°·33
	H=	0·055		H=	1·033		H=	0·014		H=	0·069
	κ=	98°·02		κ=	45°·78		κ=	102°·50		κ=	263°·34
M_2	R=	1·889	K_2	R=	0·134	ν_2	R=	0·108	$(M_2N)_4$	R=	0·062
	ζ=	303°·53		ζ=	343°·96		ζ=	357°·00		ζ=	252°·49
	H=	1·820		H=	0·179		H=	0·104		H=	0·057
	κ=	300°·10		κ=	331°·45		κ=	253°·59		κ=	342°·35
M_3	R=	0·015	P_1	R=	0·305	μ_2	R=	0·045	$(M_2K_3)_3$	R=	0·032
	ζ=	304°·33		ζ=	306°·92		ζ=	253°·20		ζ=	153°·35
	H=	0·015		H=	0·305		H=	0·042		H=	0·035
	κ=	299°·19		κ=	42°·88		κ=	246°·35		κ=	53°·64
M_4	R=	0·050	J_1	R=	0·071	R_2	R=	0·006	$(2M_2K_1)_3$	R=	0·006
	ζ=	12°·48		ζ=	237°·08		ζ=	244°·80		ζ=	300°·26
	H=	0·047		H=	0·085		H=	0·006		H=	0·006
	κ=	5°·62		κ=	43°·16		κ=	137°·86		κ=	29°·69

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·033	95°·57	0·029	358°·85
„ Fortnightly „	0·047	24·89	0·075	13·91
Luni-Solar „ „	0·059	275·88	0·057	279·30
Solar-Annual „	0·165	339·19	0·165	333·22
„ Semi-Annual „	0·055	79·43	0·055	67·51

The value of (A_0), the mean level of the sea, is 5·577 feet above the zero of the gauge, or 0·065 foot greater than last year's value.

The mean amplitude (H) of the main lunar tide (M_2) is 1·820 feet, or 0·054 foot more than last year, and its epoch is 5° less than that obtained last year.

The main solar tide (S_2) has an amplitude of 0·641 foot, which is almost the same as the preceding year's value, 0·638; the epoch of this tide is 332°·23; last year it was 336°·75.

The luni-solar tide (K_2) is this year also 10 per cent. of the main tide, while the theoretical proportion is 13 per cent.

The lunar elliptic tides (N_2 and L_2) are 24 and 3 per cent. respectively of the main tide: the former agrees with the value obtained last year, and the latter with the theoretical proportion.

The larger evectional-tide (ν_2) is 0·057 of the main tide, last year it was 0·087 of the main tide; the theoretical proportion of this tide is 0·038.

The smaller evectional tide (λ_2) is insignificant and agrees well with the theoretical proportion.

The lunar elliptic tide of the second order ($2N_2$) agrees with the value determined last year; and is only 1 per cent. greater than the theoretical proportion.

The two solar elliptic tides (T_2 and R_2) have for the first time been deduced this year; the former is 4 per cent. of the main tide, while theory gives 3 per cent. and the latter is insignificant.

The variational tide (μ_2) has a proportion of 0·023, which agrees very well with the theoretical proportion, 0·024.

Regarding the diurnal tides, the luni-solar (K_1), the lunar declinational (O_1), and the solar declinational (P_1) have very nearly the same proportions to the main tide as were obtained last year. The solar elliptic tide (Q_1) is 7 per cent. of the main tide; the lunar elliptic tide (J_1) is 5 per cent. and the lunar diurnal tide (M_1) is 3 per cent.; theoretically they should be 8, 3 and 4 per cent. respectively.

The epochs of the several diurnal tides agree very well with those determined last year, the greatest difference being in (Q_1) of $12\frac{1}{4}^{\circ}$.

The proportions of the several overtides are almost precisely the same as those found last year, and are all insignificant with the exception of the lunar (M_4).

The proportions of the compound tides also agree very closely with those of last year.

The lunar monthly tide has a proportion of 0·016 of the main tide, whereas by theory it should be 0·046; last year it was 0·027.

The lunar fortnightly tide is 0·041 of the main tide, or about half what theory assigns as its value; last year it was 0·027.

The luni-solar fortnightly tide is 0·031 of the main tide; last year it was found to be 0·012, and by theory it is quite insignificant.

The solar annual tide is 0·091 of the main tide, or just about half of what it was found to be last year. The epoch of this tide for this year is 333°, thus the time of maximum is 26 days later than last year.

The solar semi-annual tide is 0·030 of the main tide; last year it was 0·042—a value which is almost identical with theory: its epoch is 67° against 162°—last year's value.

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Madras; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

$A_0 = 2{\cdot}134$ feet.

S_1	H = R =	0·056	M_6	R =	0·008	Q_1	R =	0·006	T_2	R =	...
	κ = ζ =	99°·61		ζ =	135°·54		ζ =	215°·54		ζ =	...
S_2	H = R =	0·450		H =	0·008		H =	0·007		H =	...
	κ = ζ =	279°·79		κ =	165°·04		κ =	280°·23		κ =	...
S_4	H = R =	0·005	M_8	R =	0·002	L_2	R =	0·030	$(MS)_4$	R =	0·015
	κ = ζ =	302°·28		ζ =	99°·46		ζ =	334°·81		ζ =	7°·08
S_6	H = R =	0·001		H =	0·001		H =	0·026		H =	0·015
	κ = ζ =	63°·44		κ =	18°·81		κ =	359°·29		κ =	256°·91
S_8	H = R =	0·001	O_1	R =	0·082	N_2	R =	0·274	$(2SM)_2$	R =	0·021
	κ = ζ =	333°·44		ζ =	297°·73		ζ =	307°·65		ζ =	146°·39
				H =	0·100		H =	0·265		H =	0·021
				κ =	321°·88		κ =	238°·02		κ =	256°·55
M_1	R =	0·035	K_1	R =	0·263	λ_2	R =	0·074	$2N_2$	R =	0·064
	ζ =	11°·31		ζ =	116°·91		ζ =	212°·12		ζ =	230°·30
	H =	0·038		H =	0·296		H =	0·071		H =	0·061
	κ =	282°·99		κ =	34c°·85		κ =	73°·29		κ =	201°·21
M_2	R =	1·097	K_2	R =	0·065	ν_2	R =	0·151	$(M_2N)_4$	R =	0·109
	ζ =	358°·53		ζ =	1°·88		ζ =	125°·86		ζ =	256°·74
	H =	1·058		H =	0·086		H =	0·145		H =	0·102
	κ =	248°·36		κ =	269°·19		κ =	224°·36		κ =	76°·94
M_3	R =	0·003	P_1	R =	0·104	μ_2	R =	0·068	$(M_2K_1)_3$	R =	0·023
	ζ =	173°·66		ζ =	207°·18		ζ =	55°·18		ζ =	256°·40
	H =	0·003		H =	0·104		H =	0·063		H =	0·025
	κ =	8°·41		κ =	346°·29		κ =	194°·85		κ =	10°·18
M_4	R =	0·021	J_1	R =	0·025	R_2	R =	...	$(2M_2K_1)_3$	R =	0·005
	ζ =	86°·26		ζ =	160°·92		ζ =	...		ζ =	98°·75
	H =	0·019		H =	0·030		H =	...		H =	0·006
	κ =	225°·93		κ =	346°·06		κ =	...		κ =	14°·48

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·019	40°·77	0·017	0°·23
„ Fortnightly „	0·012	3·88	0·010	25·41
Luni-Solar „ „	0·027	18·02	0·026	128·19
Solar-Annual „	0·366	264·20	0·366	215·09
„ Semi-Annual „	0·362	235·63	0·362	137·41

The mean level of the sea (A_0) is 2·134 feet above the the zero of the gauge, which is the lowest value of all the five years' observations at this port; it differs by 0·055 foot from the mean of the three preceding years' values, which are very close to one another, and by over one-tenth of a foot from the first year's value.

The main lunar tide (M_2) has a mean amplitude (H) of 1·058, which is the largest yet obtained, but does not differ by more than 0 013 foot from the mean of the preceding four years' values. Its epoch this year is about 2° less than it was last year, and almost the same as that found in 1882-83.

The mean amplitude (H) of the main solar tide (S_2) is also higher than the values hitherto obtained, but only differs by 0·010 foot from the mean value: its epoch, however, is very nearly the same as last year, and the greatest difference in the epochs of this tide during the five years' observations is 5°, or 10 minutes in time.

The proportion of the main solar tide to the main lunar tide is 0·425; it is almost identical with last year's value and only slightly exceeds the mean of all the values previously obtained.

The luni-solar semi-diurnal tide (K_2) has a proportion of 8 per cent. of the main tide, theoretically it should be 13 per cent., last year it was 11 per cent.

The two lunar elliptic tides (N_2 and L_2) are 25 and 3 per cent. of the main tide respectively, proportions which accord fairly well with those hitherto found; the former is 6

per cent. more than the theoretical proportion, and the latter corresponds with the theoretical proportion.

The larger evectional tide (ν_2) is this year 14 per cent. of the main tide, which is almost double the proportion obtained last year, and four times the theoretical proportion.

The value of the smaller evectional tide (λ_2) is 7 per cent. of the main tide, the largest proportion yet obtained, and about 10 times the theoretical proportion.

The lunar elliptic tide of the second order ($2N_2$) is about double what theory assigns, and slightly larger than it was found to be last year.

The values of the two solar elliptical tides (T_2 and R_2), which are only evaluated every alternate year, have not been determined this year.

The variational semi-diurnal tide (μ_2) is 6 per cent. of the main tide, and about 2½ times its theoretical value; hitherto the proportions have been from 3 to 5 per cent.

The main diurnal tide (K_1) is 28 per cent. of the main tide, which has always been found to be the case at this port; theoretically it should be 58 per cent.

The lunar declinational tide (O_1) and the solar declinational tide (P_1) are each about 10 per cent. of the main tide, proportions very similar to those previously found; theoretically they should be 42 and 19 per cent.

The solar elliptic diurnal tide (Q_1) and the lunar elliptic tide (J_1) also agree in their proportions to the main tide with those previously obtained.

The lunar diurnal tide (M_1) is 0·036 of the main tide, which is the theoretical proportion, hitherto the proportions have ranged from 0·001 to 0·018.

The solar diurnal tide (S_1) has a proportion of 0·053, last year and in 1881-82 it was just half of this amount, while in 1882-83 it was 0·011, and in 1880-81, 0·035 of the main tide.

The overtides at Madras as usual are insignificant, the value of (M_4) has, however, gone up to 0·018, whereas formerly it ranged from 0·001 to 0·005.

Of the compound tides, the quarter diurnal tide $(M_2N)_4$ is the largest this year, it is 0·096 of the main tide, while last year it was 0·039, which latter is as nearly as possible the theoretical proportion.

With regard to the long period tides, the lunar monthly and the lunar fortnightly are each 0·016 and 0·019 of the main tide, which are the smallest values yet obtained at Madras; theoretically they should be 0·045 and 0·086.

The value of the luni-solar fortnightly tide agrees well with the values of the three previous years, and is considerably over the theoretical value.

The solar annual is 0·346 of the main tide, last year it was just half of the main tide, and the mean of the first three years is a close approximation to this year's value. The epoch of this tide is 215,° which would make its time of maximum about 19 days earlier than it was last year.

The solar semi-annual is 0·342 of the main tide, last year it was 29 per cent. and in the three previous years it was 25 to 36 per cent. of the main tide, while theoretically it is insignificant. The epoch of this tide is this year 137°·4, and the times of maxima are about the 25th May and 25th November.

VALUES OF THE TIDAL CONSTANTS, VIZAGAPATAM, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Vizagapatam; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0= 4·630 feet.

S_1	H = R =	0·044	M_6	R =	0·007	Q_1	R =	0·012	T_2	R =	0·036
	$\kappa = \zeta$ =	93°·63		ζ =	182°·64		ζ =	349°·56		ζ =	314°·09
S_2	H = R =	0·625		H =	0·007		H =	0·014		H =	0·036
	$\kappa = \zeta$ =	288°·28		κ =	66°·47		κ =	337°·74		κ =	282°·19
S_4	H = R =	0·003	M_8	R =	0·005	L_2	R =	0·091	$(MS)_4$	R =	0·008
	$\kappa = \zeta$ =	45°·00		ζ =	155°·90		ζ =	254°·27		ζ =	82°·09
S_6	H = R =	0·001		H =	0·004		H =	0·078		H =	0·007
	$\kappa = \zeta$ =	113°·96		κ =	241°·00		κ =	256°·26		κ =	283°·37
S_8	H = R =	0·000	O_1	R =	0·105	N_2	R =	0·309	$(2SM)_2$	R =	0·013
	$\kappa = \zeta$ =	288°·44		ζ =	359°·67		ζ =	36°·01		ζ =	60°·95
				H =	0·129		H =	0·298		H =	0·012
				κ =	333°·33		ζ =	251°·80		κ =	219°·67
M_1	R =	0·015	K_1	R =	0·318	λ_2	R =	0·041	$2N_2$	R =	0·058
	ζ =	41°·26		ζ =	116°·62		ζ =	104°·21		ζ =	347°·99
	H =	0·016		H =	0·358		H =	0·039		H =	0·056
	κ =	288°·96		κ =	342°·51		κ =	299°·35		κ =	218°·29

Short Period Tides—contd.

A_0=4 ,630 e't

M_2	R =	1·514	K_2	R =	0·124	ν_2	R =	0·098	$(M_2N)_4$	R =	0·032
	ζ =	54°·51		ζ =	8° 00		ζ =	195°·40		ζ =	1°·48
	H =	1·462		H =	0·163		H =	0·095		H =	0·030
	κ =	255°·78		κ =	279°·20		κ =	222°·81		κ =	58°·55
M_3	R =	0·010	P_1	R =	0·109	μ_2	R =	0·039	$(M_2K_1)_3$	R =	0·020
	ζ =	259° 64		ζ =	268° 34		ζ =	221°·83		ζ =	317°·95
	H =	0·009		H =	0·109		H =	0·036		H =	0·022
	κ =	21°·56		κ =	345°·49		κ =	264°·38		κ =	25°·11
M_4	R =	0·004	J_1	R =	0·020	R_2	R =	0·025	$(2M_2K_1)_3$	R =	0·014
	ζ =	184°·19		ζ =	164°·92		ζ =	216°·78		ζ =	149°·84
	H =	0·004		H =	0·024		H =	0·025		H =	0·015
	κ =	226°·74		κ =	18°·02		κ =	68°·68		κ =	326°·50

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·011	21°·52	0·010	7°·00
„ Fortnightly „ . . .	0·047	318·02	0·073	31·98
Luni-Solar „ „ . . .	0·020	240·77	0·019	39·49
Solar-Annual „ . . .	0·694	229·62	0·694	182·48
„ Semi-Annual „ . . .	0·350	222·93	0·350	128·64

The value of the mean level of the sea (A_0) is 4·63 feet above the zero of the gauge, or about 0·18 foot lower than it was in the three preceding years and double this amount lower than the 1879-80 value.

The mean amplitude (H) of the main lunar tide (M_2) is practically the same as that determined last year; the epoch, too, agrees very well with previous values.

The main solar tide (S_2) has an amplitude of 0·625 foot, which is the lowest value obtained, but it does not differ by more than 0·049 foot from the value obtained in 1879-80, which is the highest: its epoch is very accordant with former values.

The main solar tide (S_2) has a proportion of 0·427 of the main tide, the lowest yet obtained, but it does not differ by more than 0·018 from the mean of the other five years, and 0·038 from the theoretical proportion, which is 0·465.

The luni-solar semi-diurnal tide (K_2) is 11 per cent. of the main tide, which agrees very closely with the proportions of all the other years, with the exception of that for 1882-83, when it was 21 per cent. of the main tide; theoretically it should be 13 per cent.

Of the two lunar elliptic tides (N_2) the larger is 20 per cent. of the main tide, which agrees with the theoretical proportion fairly well; and also with the proportions previously determined: the smaller component (L_2) is this year just 5 per cent. of the main tide, and about double the theoretical value, 0·028; the former values vary between 0·019 and 0·061.

The larger evectional tide (ν_2) is 0·065 of the main tide, last year it was 1 per cent. greater, theoretically it should be 0·038 of the main tide; in 1881-82 it was quite insignificant, while the following year it was as much as 0·088 of the main tide. The smaller evectional tide (λ_2) is 0·027 of the main tide—just four times its theoretical value; last year it was slightly more than the theoretical proportion, and in the four years preceding it, it was double what it should be.

The lunar elliptic tide of the second order ($2N_2$) is 0·038 of the main tide, or about 1 per cent. more than the theoretical proportion, which was obtained last year.

The solar elliptic tides (T_2 and R_2) have been evaluated this year. (T_2) is 0·025 of the main tide, which is the theoretical proportion, the two former values were 0·056 and 0·014; the mean of the 3 values, however, is very close to the theoretical value: the tide (R_2) is 0·017 of the main tide, and this agrees fairly well with the other two values, 0·027 and 0·010.

The variational tide (μ_2) is this year slightly more than the theoretical proportion; and the whole of the proportions agree very well with one another.

The proportion of all the diurnal tides are very nearly the same as those found last year, and are all smaller than the theoretical proportions, which is the case in the whole of the six years' observations at this port.

The epochs of three of the diurnal tides (M_1, Q_1 and J_1) differ rather largely from the previous year's value, but those of the remaining four (K_1, O_1, P_1 and S_1) are fairly accordant.

The lunar and solar diurnal overtides are as usual all very small, and call for no special remark, which is also the case with the compound tides.

Regarding the long period tides, the lunar monthly tide is quite insignificant this year; during the other years of observations it ranged from a little over 1 per cent. to 5 per cent. of the main tide, the theoretical proportion being 0·046.

The lunar fortnightly tide is 5 per cent. of the main tide, and agrees with last year's value, the theoretical proportion is 0·086, but in the first four years the proportions were much smaller.

The luni-solar fortnightly tide is 0·013 of the main tide, a little more than the value obtained last year, but almost identical with that of 1880-81, theoretically it should be 0·007; in the first year of observation it was 5 per cent. of the main tide.

The solar-annual tide is 0·475 of the main tide, which corresponds with the mean of the other five years' values: the greatest difference in the epochs of this tide is about 21°.

The solar semi-annual tide has very nearly the same proportion to the main tide as was found last year, *viz.*, 24 per cent.; theoretically it should be only 4 per cent., but the values of this tide have never approached the theoretical, but ranged from 17 to 31 per cent.

Its epoch this year agrees with last year's and with that obtained in 1880-81 very closely; and its times of maxima appear to be about the 20th May and 20th November.

VALUES OF THE TIDAL CONSTANTS, FALSE POINT, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at False Point; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A = 0.492 feet.

S_1	H =	0·008	M_6	R =	0·004	Q_1	R =	0·004	T_2	R =	0·099
	κ =	86°·42		ζ =	214°·88		ζ =	339°·78		ζ =	38°·62
S_2	H =	1·000		H =	0·004		H =	0·005		H =	0·099
	κ =	298°·22		κ =	142°·18		κ =	187°·36		κ =	280°·00
S_4	H =	0·006	M_8	R =	0·005	L_2	R =	0·112	$(MS)_4$	R =	0·041
	κ =	306°·67		ζ =	77°·01		ζ =	197°·82		ζ =	44°·90
S_6	H =	0·005		H =	0·004		H =	0·095		H =	0·039
	κ =	158°·20		κ =	220°·08		κ =	286°·15		κ =	260°·66
S_8	H =	0·005	O_1	R =	0·140	N_2	R =	0·455	$(2SM)_2$	R =	0·029
	κ =	181°·10		ζ =	71°·03		ζ =	97°·68		ζ =	68°·50
				H =	0·172		H =	0·439		H =	0·028
				κ =	333°·70		κ =	258°·37		κ =	212°·73
M_1	R =	0·008	K_1	R =	0·359	λ_2	R =	0·069	$2N_2$	R =	0·052
	ζ =	317°·05		ζ =	29°·49		ζ =	146°·71		ζ =	134°·61
	H =	0·009		H =	0·406		H =	0·066		H =	0·050
	κ =	226°·80		κ =	341°·23		κ =	272°·09		κ =	240°·22
M_2	R =	2·320	K_2	R =	0·220	ν_2	R =	0·141	$(M_2N)_4$	R =	0·051
	ζ =	51°·29		ζ =	212°·16		ζ =	174°·43		ζ =	10°·38
	H =	2·237		H =	0·292		H =	0·136		H =	0·047
	κ =	267°·05		κ =	295°·23		κ =	300°·58		κ =	26°·84
M_3	R =	0·017	P_1	R =	0·132	μ_2	R =	0·046	$(M_2K_1)_3$	R =	0·014
	ζ =	243°·44		ζ =	293°·66		ζ =	180°·89		ζ =	59°·32
	H =	0·016		H =	0·132		H =	0·042		H =	0·015
	κ =	27°·09		κ =	344°·08		κ =	152°·43		κ =	226°·83
M_4	R =	0·031	J_1	R =	0·017	R_2	R =	0·014	$(2M_2K_1)_3$	R =	0·009
	ζ =	161°·50		ζ =	351°·28		ζ =	345°·04		ζ =	240°·82
	H =	0·029		H =	0·020		H =	0·014		H =	0·010
	κ =	233°·04		κ =	359°·46		κ =	283°·66		κ =	0°·61

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·016	347°·83	0·014	42°·90
„ Fortnightly „	0·063	161·98	0·099	32·42
Luni-Solar „ „	0·015	97·87	0·014	242·10
Solar-Annual „	0·888	122·07	0·888	161·65
„ Semi-Annual „	0·260	78·73	0·260	157·89

The mean level of the sea (A_0) is found to be 7·492 feet above the zero of the gauge, which is exactly one-tenth of a foot lower than last year, and 0·067 foot lower than the mean value obtained from the whole four years' observations.

The mean amplitude (H) of the main lunar tide (M_2) is 2·237 feet, it is the lowest value obtained, but does not differ by more than 0·03 of a foot from last year's value, and is only 0·014 foot less than the mean of all the amplitudes. The epochs are very accordant, the greatest difference being about 4°, or 8 minutes in time.

The mean amplitude (H) of the main solar, tide (S_2) is very accordant with all the previous values; its epoch, too, is well determined there being only a difference of about 6° between the largest and smallest values, or about 12 minutes in time.

The proportion of the main solar tide to the main lunar tide is 0·447, which is precisely the same as the 1881-82 value, and also the mean of the other two years' values; the theoretical proportion is slightly greater, being 0·465.

The luni-solar semi-diurnal tide (K_2) is again 13 per cent. of the main tide, which is also the theoretical proportion. The epoch of this tide agrees with the first two, but is about 12° less than last year's.

The two lunar elliptic tides (N_2 and L_2) are 1 per. cent. greater than last year, but the former has a proportion equal to the theoretical, and the latter a somewhat greater proportion.

The evectional tide (ν_2) has a proportion of 0·061, which is close to the mean of the first two years' results, last year it was 0·016, and the theoretical proportion is 0·038.

The other evectional tide (λ_2) is 0·030 of the main tide, last year it was 0·008, which is nearly the theoretical proportion, and in the two first years the proportions were 0·020 and 0·036.

The lunar elliptic tide of the second order ($2N_2$) has a proportion very similar to that of last year's, and also agrees very well with the theoretical proportion.

The two solar elliptic tides (T_2 and R_2) are respectively 0·044 and 0·006 of the main tide, the former is about five times as large as it was in 1882-83, and one and a half times the theoretical proportion, but the latter is fairly accordant with the value determined in 1882-83.

The variational tide (μ_2) is 0·019 of the main tide, and is a closer approach to the theoretical value than any of the other three years' results, which were 0·030, 0·036 and 0·031.

Of the diurnal tide, it may be said that the proportions of all agree with those previously obtained, and are all less than the theoretical proportions, and it may also be remarked that the proportions of the three principal tides (K_1, O_1 and P_1) to the main tide are smaller than they are either at Madras or Vizagapatam. The epochs of three of the diurnal tides (O_1, K_1 and P_1) are all very accordant, but those of (S_1, J_1 and M_1) have not been well determined, while that of the remaining tide (Q_1) were for the first three years 306°, 340° and 31°, and this year the epoch is only 187°.

The overtides are all insignificant as usual, the largest of them is (M_4) and this is only a little more than 1 per cent. of the main tide; the several values of its epoch are very near one another, the greatest difference being 12°, or about 12 minutes in time.

The compound tides agree very well with previous values, but do not call for further remark.

With regard to the long-period tides, the lunar monthly is this year very small, it being only 0·006 of the main tide, the other three values of this tide ranged from 0·020 to 0·032, its theoretical value being over 0·045.

The lunar fortnightly tide is this year 0·044 of the main tide, or about half of what it should be, the other values of this tide were even smaller.

The luni-solar fortnightly tide is insignificant this year, which it ought to be; in former years it was about 2 per cent. of the main tide.

The solar annual tide is 0·397 of the main tide, or about 2 per cent. higher than the mean of the two preceding years' values and about 6 per cent. more than the first year's value. The greatest discrepancy in its epoch is 10° and its time of maximum is about the 3rd September.

The solar semi-annual tide is again 12 per cent. of the main tide, the two first values were 9 and 16 per cent., while by theory it should be only 4 per cent. of the main tide: its epoch is this year 158°, or about 4° more than last year, the largest difference, however, between the epochs is only about 16°, and its times of maxima may be said to be about the 4th June and 4th December.

VALUES OF THE TIDAL CONSTANTS, DUBLAT, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Dublat; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=14·379 feet.

S_1	H = R =	0·047	M_6	R =	0·014	Q_1	R =	0·010	T_2	R =	0·175
	κ = ζ =	124°·40		ζ =	299°·14		ζ =	118°·89		ζ =	170°·45
S_2	H = R =	2·071		H =	0·013		H =	0·012		H =	0·175
	κ = ζ =	326°·36		κ =	165°·08		κ =	312°·40		κ =	60°·70
S_4	H = R =	0·015	M_8	R =	0·007	L_2	R =	0·200	$(MS)_4$	R =	0·076
	κ = ζ =	255°·12		ζ =	0°·99		ζ =	109°·64		ζ =	101°·88
S_6	H = R =	0·001		H =	0·006		H =	0·170		H =	0·074
	κ = ζ =	59°·04		κ =	302°·24		κ =	299°·65		κ =	177°·20
S_8	H = R =	0·002	O_1	R =	0·148	N_2	R =	0·907	$(2SM)_2$	R =	0·060
	κ = ζ =	58°·39		ζ =	212°·05		ζ =	144°·80		ζ =	273°·40
				H =	0·183		H =	0·875		H =	0·058
				κ =	343°·00		κ =	282°·67		κ =	198°·08
M_1	R =	0·020	K_1	R =	0·434	λ_2	R =	0·065	$2N_2$	R =	0·208
	ζ =	246°·62		ζ =	47°·31		ζ =	33°·81		ζ =	52°·22
	H =	0·024		H =	0·490		H =	0·063		H =	0·200
	κ =	264°·52		κ =	350°·29		κ =	276°·85		κ =	252°·65
M_2	R =	4·796	K_2	R =	0·478	ν_2	R =	0·287	$(M_2N)_4$	R =	0·054
	ζ =	215°·06		ζ =	267°·24		ζ =	215°·08		ζ =	216°·96
	H =	4·626		H =	0·634		H =	0·276		H =	0·050
	κ =	290°·38		κ =	332°·77		κ =	302°·68		κ =	70°·14
M_3	R =	0·051	P_1	R =	0·156	μ_2	R =	0·115	$(M_2K_1)_3$	R =	0·048
	ζ =	19°·64		ζ =	290°·82		ζ =	204°·49		ζ =	123°·29
	H =	0·048		H =	0·156		H =	0·107		H =	0·053
	κ =	132°·61		κ =	350°·11		κ =	355°·12		κ =	141°·58
M_4	R =	0·093	J_1	R =	0·044	R_2	R =	0·095	$(2M_2K_1)_3$	R =	0·047
	ζ =	358°·31		ζ =	120°·25		ζ =	16°·94		ζ =	276°·63
	H =	0·086		H =	0·053		H =	0·095		H =	0·050
	κ =	148°·94		κ =	2°·05		κ =	306°·69		κ =	124°·28

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·030	105°·72	0·027	43°·17
„ Fortnightly „ . . .	0·055	41·07	0·086	34·48
Luni-Solar „ „ . . .	0·028	309·16	0·027	233·84
Solar-Annual „ . . .	0·930	114·80	0·930	145·51
„ Semi-Annual „ . . .	0·211	100·50	0·211	161·91

The value of the mean level of the sea (A_0) is 14·379 feet above the zero of the gauge, which is about the same as the value obtained in 1881-82; the mean value of the mean sea-level from the four years' observations is 14·422 feet

The mean amplitude (H) of the main lunar tide (M_2) is 4·626 feet and corresponds with that determined from the first year's observations, this value is only 0·03 foot higher than the mean of the other two years, which is 4·595 feet. The epochs are all very accordant, the greatest difference being less than 1°, or about 1½ minutes in time.

The mean amplitude (H) of the main solar tide (S_2) is 2·071 foot, which agrees fairly well with the value derived in 1881-82, but it is about 0·08 foot less than the mean of the other two years' results. The epochs of this tide also are all very accordant, there being no greater difference than 2½°, or 5 minutes in time.

The proportion of the main solar to the main lunar tide is 0·448, or very nearly the same as in 1881-82; the mean proportion from the four years' observations is 0·458, which is very close to the theoretical value, 0·465.

The luni-solar semi-diurnal tide (K_2) is about 1 per cent. more than the theoretical proportion, but the last three years' values are very close to one another and the first year's value agreed with theory. The epochs of this tide vary between 310° and 333°.

The results of the two lunar elliptic tides (N_2 and L_2) vary but little from those of last year, the former is just about the theoretical proportion to the main tide and was so in the two preceding years, but in the first year of observation it was about 3 per cent. greater, while the latter tide is this year 1 per cent. greater than the theoretical propor-

tion to the main tide, but agrees with the proportions found during the two first years. The epochs of these tides agree very well.

The larger evectional tide (ν_2) has double the proportion to the main tide that it had last year, *viz.*, 0·060, but it agrees with the first year's value, while for the other two years very nearly the theoretical proportion was obtained.

The smaller evectional tide (λ_2) is just double the theoretical proportion and accords with the proportion obtained last year, but in the other two years the proportions were much higher, *viz.*, in 1882-83, 0·030, which is about 5 times the theoretical value, and in 1881-82, 0·064, or 10 times as large as it should be.

The epochs of these two tides are very variable.

The lunar elliptic tide of the second order ($2N_2$) is twice as large as it was found to be last year, and nearly double the theoretical proportion, 0·026.

The solar elliptic tides (T_2 and R_2) have been deduced this year, the former is nearly 4 per cent. of the main tide, or about 1 per cent. greater than it should be by theory; the latter tide is just about half of the value found in 1882-83.

The variational semi-diurnal tide (μ_2) agrees with the theoretical value and with what was obtained in 1882-83, in 1881-82 the proportion was about double what it ought to have been, and in 1883-84 it was too great by about a half.

The proportion of all the diurnal tides to the main tide throughout the four years' observations at this place, are very accordant; those of the three principal ones (K_1, O_1 and P_1) are respectively 11, 4 and 3 per cent., while theoretically they should be 58, 42 and 19 per cent., and their epochs are well determined.

The overtides are all as usual unimportant, and the same may be said of the compound tides.

The long period tides, as is usual, at Dublat, have been found to be small. The three lunar tides (Mm, Mf, and Msf) are respectively 1, 2 and 1 per cent. of the main tide, while theoretically they should be 5, 9 and 1 per cent.

The solar annual tide is 20 per cent., and the solar semi-annual 5 per cent. of the main tide: the last-mentioned agrees very well with theory. The epoch of the solar annual tide has been fairly well determined, and the time of maximum varies between the 13th and 22nd August. The epoch of the semi-annual is not so well determined, the times of maxima being between the 15th May and 10th June and 15th November and 10th December.

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=10·669 feet.

S_1	H=		M_6	R=	0·174	Q_1	R=	0·028	T_2	R=	0·175
	R=	0·082		ζ=	351°·73		ζ=	45°·74		ζ=	263°·54
	κ=	200°·48		H=	0·156		H=	0·034		H=	0·175
S_2	H=			κ=	325°·37		κ=	350°·28		κ=	184°·34
	R=	1·462	M_8	R=	0·077	L_2	R=	0·178	$(MS)_4$	R=	0·647
	ζ=	103°·66		ζ=	188°·60		ζ=	242°·53		ζ=	333°·71
S_4	H=			H=	0·067		H=	0·151		H=	0·625
	R=	0·080		κ=	273°·46		κ=	62°·61		κ=	84°·92
	ζ=	118°·10	O_1	R=	0·171	N_2	R=	0·686	$(2SM)_2$	R=	0·069
S_6	H=			ζ=	186°·33		ζ=	186°·20		ζ=	123°·85
	R=	0·001		H=	0·210		H=	0·662		H=	0·066
	ζ=	194°·04		κ=	23°·30		κ=	44°·99		κ=	12°·04
S_8	H=R=	0·007	K_1	R=	0·353	λ_2	R=	0·057	$2N_2$	R=	0·131
	κ=	235°·01		ζ=	142°·26		ζ=	144°·81		ζ=	67°·99
				H=	0·398		H=	0·055		H=	0·127
M_1	R=	0·045		κ=	55°·02		κ=	72°·92		κ=	34°·36
	ζ=	229°·85	K_2	R=	0·369	ν_2	R=	0·330	$(M_2N)_4$	R=	0·113
	H=	0·052		ζ=	93°·10		ζ=	290°·12		ζ=	257°·60
	κ=	260°·29		H=	0·489		H=	0·318		H=	0·105
M_2	R=	3·808		κ=	98°·13		κ=	44°·43		κ=	227°·61
	ζ=	308°·65	P_1	R=	0·153	μ_2	R=	0·237	$(M_2K_1)_3$	R=	0·078
	H=	3·674		=	321°·18		ζ=	320°·22		ζ=	36°·98
	κ=	59°·87		H=	0·153		H=	0·220		H=	0·085
M_3	R=	0·046		κ=	51°·03		κ=	182°·65		κ=	60°·96
	ζ=	177°·16	J_1	R=	0·026	R_2	R=	0·123	$(2M_2K_1)_3$	R=	0·031
	H=	0·043		ζ=	243°·44		ζ=	180°·14		ζ=	14°·83
	κ=	343°·98		H=	0·031		H=	0·123		H=	0·032
M_4	R=	0·783		κ=	50°·10		κ=	79°·34		κ=	324°·49
	ζ=	177°·91									
	H=	0·729									
	κ=	40°·34									

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·325	119°·83	0·288	12°·25
„ Fortnightly „	0·152	156·43	0·238	53·71
Luni-Solar „ „	0·864	154·16	0·834	42·95
Solar-Annual „	2·361	161·75	2·361	161·90
„ Semi-Annual „	0·651	352·91	0·651	353·22

The mean level of the river at Kidderpore (A_0) is 10·669 feet above the zero of the gauge, which zero corresponds to the level of the sill of the Kidderpore Dock, the value is 0·07 foot higher than last year and 0·013 foot less than the mean of the values determined up to date.

The main lunar tide (M_2) has an amplitude of 3·674 feet, which very nearly corresponds with the 1882-83 value, but it is 0·028 foot greater than last year's value, and in the first year of observation the value of the amplitude was 3·593 feet. Its epoch is 2° more than in the two preceding years and 1°·3 more than the first year's value.

The main solar tide (S_2) is 1·462 in amplitude, or about 0·05 foot lower than in the two years immediately preceding and 0·04 foot greater than the first year's value. The epoch agrees very well with last year's and is only 3° different from that of 1882-83, which has the lowest value.

The proportion between these two tides is precisely the same as in 1881-82, *viz.*, 0·398, while in 1882-83 and 1883-84 it was slightly higher, the theoretical proportion being 0·065.

The luni-solar semi-diurnal tide (K_2) is a little over 13 per cent. of the main tide, and agrees very closely with the preceding year's proportion; the value of the other two years' observations were about 12 per cent., the theoretical proportion being 12½ per cent. Its epoch is fairly well determined, the greatest difference in any two years' observations being less than 13°.

The lunar elliptic tides (N_2 and L_2) correspond very well in their proportions to the main tide with the values previously obtained and approach the theoretical proportion, the epoch of the larger tide (N_2) has been well determined, but that of (L_2) varies about 27°.

Of the two evectional tides (ν_2 and λ_2), the former is 9 per cent. of the main tide and agrees with the first year's value, but is double that of the other two years', when the theoretical proportion was approached; the latter tide has a proportion of 0·015 of the main tide, which is just about double what it should be by theory, while in the other three years the proportions were much higher. The values of the epochs of these two tides are very irregular.

The lunar elliptic tide of the second order ($2N_2$) has a proportion similar to that obtained last year and is slightly larger than it should be.

The two solar elliptic tides (T_2 and R_2) are 0·048 and 0·033 of the main tide, values not very different from those obtained before.

The proportion of the variational tide (μ_2) to the main tide is 0·060, which was the value first obtained in 1881-82, and is 2 and 1 per cent. respectively less than in the two years immediately preceding.

With regard to the diurnal tides, the luni-solar (K_1) this year is 11 per cent. of the main tide, and so are all the other values. The lunar declinational tide (O_1) is 6 per cent. and the solar declinational (P_1) 4 per cent. of the main tide, which values have always been found. The values of the epochs of these three tides are very accordant. The other diurnal tides are all very small as usual. The proportions of all the diurnal tides to the main tide are very much smaller than they ought to be by theory, but this is noticeable in all the Hooghly ports.

The lunar (M_4) is the most important overtide, its proportion to the main tide is 20 per cent. and this value has always been obtained; the remaining overtides all agree in their proportions to the main tide with those hitherto found.

The proportions of the compound tides are all almost identical with those obtained in the preceding year.

The lunar monthly tide is 8 per cent. of the main tide again this year and is very nearly double of what it should be; of the four values now obtained, that of 1882-83 only approaches the theoretical proportion.

The lunar fortnightly tide is 0·065 of the main tide, the lowest value yet found; in the other three years the values were near the theoretical proportion, 0·086. The luni-solar fortnightly tide is 23 per cent. of the main tide, while by theory it is insignificant, but the proportion has always been found high at Kidderpore.

The solar annual tide bears very nearly the same proportion to the main tide as it did last year, and is about 10 per cent. less than the values of the other two years.

The solar semi-annual tide is this year only 18 per cent. of the main tide, while in the two preceding years it was over 19 per cent., and in the first year it was 26 per cent.; the theoretical value of this tide is only 4 per cent. of the main tide.

The epochs of the lunar monthly tide are very irregular, those of the lunar fortnightly show a difference of 18°, but those of the luni-solar fortnightly are more accordant, the greatest difference being about 12°.

The epoch of the solar annual is 12° greater than last year and about 4° greater than the values of 1881-82 and 1882-83. The time of maximum appears to be between the 17th and 29th August

The values of the epoch of the solar semi-annual are very discordant.

VALUES OF THE TIDAL CONSTANTS, ELEPHANT POINT, 1884.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884 observations at Elephant Point; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884 observations:—

Short Period Tides.

$A_0 = 16{\cdot}314$ feet.

S_1	H = R =	0·140	M_6	R	0·280	Q_1	R	0·035	T_2	R =	...
	κ = ζ =	91°·02		ζ	198°·23		ζ	205°·68		ζ =	...
S_2	H = R =	2·384		H	0·252		H	0·043		H =	...
	κ = ζ =	139°·57		κ	338°·65		κ	23°·11		κ =	...
S_4	H = R =	0·092	M_8	R	0·123	L_2	R	0·508	$(MS)_4$	R =	0·322
	κ = ζ =	181°·37		ζ	256°·52		ζ	101°·71		ζ =	194°·91
S_6	H = R =	0·013		H	0·107		H	0·440		H =	0·310
	κ = ζ =	294°·19		κ	323°·75		κ	116°·82		κ =	121°·72
S_8	H = R =	0·009	O_1	R	0·282	N_2	R	0·995	$(2SM)_2$	R =	0·168
	κ = ζ =	307°·49		ζ	274°·29		ζ	77°·30		ζ =	328°·97
				H	0·344		H	0·961		H =	0·163
				κ	5°·59		κ	90°·24		κ =	42°·16
M_1	R =	0·037	K_1	R	0·644	λ_2	R	0·195	$2N_2$	R =	0·291
	ζ =	99°·95		ζ	185°·90		ζ	255°·15		ζ =	348°·37
	H =	0·039		H	0·723		H	0·188		H =	0·281
	κ =	25°·54		κ	19°·52		κ	161°·97		κ =	87°·44
M_2	R =	6·086	K_2	R	0·745	ν_2	R	0·137	$(M_2N)_4$	R =	0·252
	ζ =	175°·07		ζ	273°·86		ζ	300°·72		ζ =	94°·01
	H =	5·876		H	0·980		H	0·132		H =	0·235
	κ =	101°·88		κ	120°·49		κ	67°·51		κ =	33°·75
M_3	R =	0·022	P_1	R	0·162	μ_2	R	0·371	$(M_2K_1)_3$	R =	0·067
	ζ =	124°·95		ζ	208°·15		ζ	59°·72		ζ =	305°·83
	H =	0·021		H	0·162		H	0·346		H =	0·073
	κ =	15°·16		κ	17°·86		κ	273°·33		κ =	66°·26
M_4	R =	0·289	J_1	R	0·024	R_2	R	...	$(2M_2K_1)_3$	R =	0·066
	ζ =	224°·97		ζ	327°·95		ζ	...		ζ =	330°·61
	H =	0·270		H	0·029		H	,,		H =	0·069
	κ =	78°·58		κ	77°·32		κ	...		κ =	350°·60

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·135	75°·01	0·120	348°·88
„ Fortnightly „ . . .	0·123	85·66	0·190	9·87
Luni-Solar „ „ . . .	0·234	343·03	0·226	56·23
Solar-Annual „ . . .	0·812	196·92	0·812	117·21
„ Semi-Annual „ . . .	0·134	3·51	0·134	204·09

The mean level of the water (A_0) as determined from this (1884), the first year's observations, is 16·314 feet above the zero of the gauge.

During 1880-81 observations were taken at a site which had to be abandoned, the results obtained at the new site in 1884 will be compared with the old values at the old site in 1880-81.

The mean amplitude (H) of the main lunar tide (M_2) is 5·876 feet, which is almost identical with the value obtained at the old site; its epoch, too, agrees very closely.

The amplitude of the main solar tide (S_2) is 2·384 feet, or 0·05 foot greater than the value obtained at the old site; its epoch is 3½° less. The proportion of the main solar tide to the main lunar tide is 0·406, which is very nearly the same proportion as obtained at the old site, and about 6 per cent. less than what theory would give.

The luni-solar semi-diurnal tide (K_2) is this year 17 per cent. of the main tide, or about 4 per cent. greater than it should be, while in 1880-81 it was only 7 per cent. Its epoch is 29° later.

The large lunar elliptic tide (N_2) is 16 per cent. of the main tide, which is 10 per cent. less than the value at the old site, but is nearer the theoretical proportion, which is 19 per cent.

The smaller lunar elliptic tide (L_2) has a somewhat greater proportion to the main tide than was obtained at the old site, and is about 2½ times as large as it should be.

Of the two evectional tides (ν_2) and (λ_2) the proportions obtained for them are very much less than at the old site, *viz.*, 0·022 and 0·032 of the main tide, against 0·116 and 0·112; their theoretical proportions are 0·038 and 0·007.

The value of the lunar elliptic tide of the second order ($2N_2$) is about 5 per cent. of the main tide and nearly double the theoretical value, while at the old site it is about 9 per cent. of the main tide.

The variational tide (M_3) is 0·06 of the main tide, this proportion is almost identical with the 1880-81 values at the old site, and is a little more than double what it should be by theory.

The proportions of the three principal diurnal tides (K_1, O_1 and P_1) are 12, 6 and 3 per cent. of the main tide respectively; these values are very accordant with those found in 1880-81 at the old site and also with those of the same tides at Amherst, but they are all much smaller than their theoretical values, *viz.*, 58, 42 and 19 per cent. The values of the epochs of (K_1, Θ_1 and P_1) agree very well with the values obtained at the old site.

The other diurnal tides agree in their proportions to the main tide with the values obtained at the old site.

Regarding the overtides, they all agree fairly well in their proportions to the main tide, with the values at the old site, with the exception of the lunar (M_4) which is 0·046 of the main tide, the other value at the old site is just over 1 per cent., but the value now deduced agrees with the value of this tide at Amherst.

The values of the compound tides are all accordant with the values deduced for them at Amherst.

Regarding the long period tides, the lunar monthly tide is just 2 per cent. of the main tide, and agrees with the 1880-81 value at the old site. The lunar fortnightly is twice as large as it was in 1880-81 at the old site, but is less than half of what it should be theoretically, being 0·032 of the main tide instead of 0·086. The luni-solar fortnightly tide is nearly 4 per cent. of the main tide, in 1880-81 it was 1 per cent., which is as near as possible the theoretical proportion.

The solar annual tide is 14 per cent. of the main tide; in 1880-81, at the old site it was 16 per cent. Its epoch is about a month earlier than in 1880-81, making its time of maximum the 16th July instead of the 15th August.

The solar semi-annual tide is 2 per cent. of the main tide; in 1880-81, at the old site, it was 4 per cent., which is its theoretical proportion. Its epoch is about six days later than in 1880-81 at the old site.

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Rangoon: and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=14·739 feet.

S_1	H = R =	0·105	M_6	R =	0·251	Q_1	R =	0·029	T_2	R =	...
	κ = ζ =	128°·52		ζ =	17°·32		ζ =	6°·56		ζ =	...
S_2	H = R =	2·021		H =	0·226		H =	0·036		H =	...
	κ = ζ =	171°·70		κ =	88°·72		κ =	38°·76		κ =	...
S_4	H = R =	0·088	M_8	R =	0·102	L_2	R =	0·520	$(MS)_4$	R =	0·400
	κ = ζ =	264°·56		ζ =	124°·01		ζ =	92°·83		ζ =	310°·43
S_6	H = R =	0·011		H =	0·089		H =	0·444		H =	0·386
	κ = ζ =	32°·12		κ =	99°·20		κ =	150°·31		κ =	214°·23
S_8	H = R =	0·007	O_1	R =	0·234	N_2	R =	1·088	$(2SM)_2$	R =	0·160
	κ = ζ =	96°·71		ζ =	21°·39		ζ =	189°·99		ζ =	313°·44
				H =	0·287		H =	1·050		H =	0·154
				κ =	31°·36		κ =	116°·01		κ =	49°·64
M_1	R =	0·028	K_1	R =	0·593	λ_2	R =	0·332	$2N_2$	R =	0·241
	ζ =	128°·34		ζ =	145°·67		ζ =	325°·85		ζ =	126°·11
	H =	0·031		H =	0·668		H =	0·320		H =	0·233
	κ =	51°·58		κ =	37°·90		κ =	168°·65		κ =	74°·36

Short Period Tides—contd.

A_0=14·739 feet.

M_2	R=	5·840	K_2	R=	0·437	ν_2	R=	0·526	$(M_2N)_4$	R=	0·103
	ζ=	228°·30		ζ=	208°·73		ζ=	324°·30		ζ=	201°·36
	H=	5·635		H=	0·578		H=	0·508		H=	0·036
	κ=	132°·10		κ=	172°·65		κ=	109°·09		κ=	31°·18
M_3	R=	0·032	P_1	R=	0·167	μ_2	R=	0·543	$(M_2K_1)_3$	R=	0·091
	ζ=	213°·99		ζ=	304°·13		ζ=	120°·39		ζ=	267°·40
	H=	0·031		H=	0·167		H=	0·506		H=	0·099
	κ=	69°·69		κ=	54°·70		κ=	287°·99		κ=	63°·43
M_4	R=	0·450	J_1	R=	0·032	R_2	R=	...	$(2M_2K_1)_3$	R=	0·110
	ζ=	3°·54		ζ=	218°·33		ζ=	...		ζ=	145°·19
	H=	0·419		H=	0·039		H=	...		H=	0·116
	κ=	171°·13		κ=	89°·93		κ=	...		κ=	60°·56

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·193	26°·85	0·171	4°·62
„ Fortnightly „ . . .	0·173	325·06	0·270	28·91
Luni-Solar „ „ . . .	0·549	315·17	0·530	51·37
Solar-Annual „ . . .	1·201	166·40	1·201	145·83
„ Semi-Annual „ . . .	0·071	304·41	0·071	263·27

The mean level of the river (A_0) is 14·739 feet above the zero of the gauge, it is the lowest value obtained and is 0·244 feet less than the mean of the preceding four years' observations.

The mean amplitude (H) of the main lunar tide (M_2) is 5·635 feet and is 0·079 foot higher than the mean of the previous four years' results; its epoch is well established.

The mean amplitude of the main solar tide (S_2) compares well with the 1882-83 value and is about 0·02 foot more than the other three values found. Its epoch also is well established.

The luni-solar semi-diurnal tide (K_2) is again 10 per cent. of the main tide; this value has always been obtained, the theoretical proportion is 3 per cent. greater. Its epoch this year is 172°·6, which is practically the same as it was in 1881-82 and is about 5° more than in the remaining three years of observation.

The larger lunar elliptic tide (N_2) has this year almost the same proportion to the main tide as in 1880-81, and is very slightly less than it should be, in fact, in the whole five years of observation the proportion agrees very well. The smaller lunar elliptic tide (L_2) is this year 8 per cent. of the main tide, which agrees with the previous year's value; in 1882-83 it was 9 per cent. and in the other two years it was about 6 per cent., the theoretical value being about 3 per cent. The epochs of the larger tide (N_2) for the several years are all very similar, while those of the smaller (L_2) show a difference of about 17° between the greatest and least values.

The evectional tide (ν_2) is 9 per cent. of the main tide, which accords well with the first year's proportion, in the other three years it was from 3 to 7 per cent., which is nearer the theoretical value. The proportion of the other evectional tide (λ_2) is nearly 6 per cent. of the main tide, and agrees with the results of the first two years, but in the other two years it was about 3 per cent. The values of the epochs of these two tides are irregular.

The lunar elliptic tide of the second order ($2N_2$) is 0·041 of the main tide, the other value deduced was just about half of this amount, while by theory it should be 0·026 of the main tide.

The variational tide (μ_2) agrees in its proportion to the main tide with the values hitherto determined and is nearly four times as large as it should be.

The values of the three principal diurnal tides (K_1, O_1 and P_1) are very nearly the same for the whole five years of observation, and are respectively 12, 5 and 3 per cent. of the main tide, these are all much smaller than they should be by theory, but they correspond with the values obtained for these tides at Kidderpore, Elephant Point, Amherst and Moulmein. The epochs of these three diurnal tides have been fairly well determined.

The remaining diurnal tides are all as usual insignificant.

There is nothing special to say regarding the several overtides and compound tides, their proportions to the main tide remaining the same as those already found.

The lunar monthly tide is 0·003 of the main tide, or 1½ per cent. less than it should be; this value, however, agrees with that of 1882-83: in 1880-81 and 1883-84 it was about 5

per cent. of the main tide, while in 1881-82 very nearly the theoretical proportion was found.

The lunar fortnightly tide is about 5 per cent. of the main tide: although less than the theoretical proportion, it is the highest yet obtained; but the values in all the five years agree well with one another.

The proportion of the luni-solar fortnightly tide to the main tide agrees very well with former values, although it is about thirteen times greater than the theoretical value.

The solar annual tide is 21 per cent. of the main tide, which is the least value obtained for it at Rangoon, the other values were from 25 to 29 per cent. The epoch of this tide is fairly accordant with former values, its time of maximum being between the 12th and 25th August.

The solar semi-annual tide is a little over 1 per cent. of the main tide: in 1881-82 this tide was very small, and in the other three years of observation it was three per cent. of the main tide, or about 1 per cent. less than it should be theoretically.

The epoch of this tide is very variable.

VALUES OF THE TIDAL CONSTANTS, MOULMEIN, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Moulmein, and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=8·146 feet.

S_1	H = R =	0·114	M_6	R =	0·086	Q_1	R =	0·046	T_2	R =	...
	κ = ζ =	143°·69		ζ =	334°·43		ζ =	52°·73		ζ =	...
S_2	H = R =	1·364		H =	0·077		H =	0·056		H =	...
	κ = ζ =	150°·10		κ =	208°·07		κ =	79°·36		κ =	...
S_4	H = R =	0·071	M_8	R =	0·050	L_2	R =	0·389	$(MS)_4$	R =	0·741
	κ = ζ =	222°·67		ζ =	47°·87		ζ =	236°·56		ζ =	17°·55
S_6	H = R =	0·007		H =	0·043		H =	0·330		H =	0·714
	κ = ζ =	246°·37		κ =	119°·40		κ =	123°·33		κ =	215°·44
S_8	H = R =	0·002	O_1	R =	0·222	N_2	R =	0·643	$(2SM)_2$	R =	0·160
	κ = ζ =	120°·96		ζ =	157°·06		ζ =	126°·26		ζ =	247°·85
				H =	0·273		H =	0·620		H =	0·155
				κ =	55°·47		κ =	92°·37		κ =	49°·67
M_1	R =	0·017	K_1	R =	0·404	λ_2	R =	0·189	$2N_2$	R =	0·085
	ζ =	43°·28		ζ =	105°·87		ζ =	204°·57		ζ =	50°·44
	H =	0·019		H =	0·456		H =	0·183		H =	0·082
	κ =	121°·57		κ =	43°·96		κ =	153°·28		κ =	144°·78
M_2	R =	4·030	K_2	R =	0·207	ν_2	R =	0·451	$(M_2N)_4$	R =	0·218
	ζ =	275°·77		ζ =	102°·72		ζ =	220°·71		ζ =	231°·76
	H =	3·887		H =	0·275		H =	0·435		H =	0·203
	κ =	113°·66		κ =	158°·46		κ =	127°·76		κ =	35°·75
M_3	R =	0·020	P_1	R =	0·145	μ_2	R =	0·344	$(M_2K_1)_3$	R =	0·148
	ζ =	180°·29		ζ =	348°·34		ζ =	224°·40		ζ =	327°·43
	H =	0·019		H =	0·145		H =	0·320		H =	0·162
	κ =	117°·12		κ =	52°·59		κ =	260°·17		κ =	103°·41
M_4	R =	0·974	J_1	R =	0·013	R_2	R =	...	$(2M_2K_1)_3$	R =	0·094
	ζ =	137°·02		ζ =	251°·70		ζ =	...		ζ =	319°·73
	H =	0·906		H =	0·016		H =	...		H =	0·099
	κ =	172°·78		κ =	62°·95		κ =	...		κ =	57°·40

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	0·388	133°·31	0·344	5°·08
„ Fortnightly „ . . .	0·138	170·90	0·217	31·98
Luni-Solar „ „ . . .	1·089	240·37	1·050	42·49
Solar-Annual „ . . .	2·032	117·77	2·032	143·52
„ Semi-Annual „ . . .	0·501	216·19	0·501	267·69

The mean level of the river (A_0) at Moulmein as found this year is 8·146 feet above the zero of the gauge, or 0·591 foot lower than in the preceding year; it is also 0·513 foot lower than the values in 1881-82 and 1882-83, and 0·307 foot lower than the other value in 1880-81; it differs from the mean of all the preceding years by nearly half a foot.

The value of the amplitude of the main lunar tide (M_2) is almost exactly the same as in 1880-81, but is 0·162 foot higher than the mean value of the other three years. The epoch of this tide is well established.

The main solar tide (S_2) is 0·019 foot more in amplitude than it was during the preceding three years, and nearly double this amount less than the value found in 1880-81; the greatest difference in the epochs of this tide is about 5°, or 10 minutes in time. The proportion of this tide to the main tide corresponds very closely to those previously obtained.

The luni-solar semi-diurnal tide (K_2) is 7 per cent. of the main tide, which is very near the value obtained in 1881-82; the other values are from 8 to 11 per cent., while accordingly to theory it should be 13 per cent. of the main tide.

The two lunar elliptic tides (N_2 and L_2) are respectively 16 and 9 per cent. of the main tide; these values compare very well with previous ones, excepting the value of (L_2) in 1881-82, which is exceptionally large: the theoretical values for (N_2 and L_2) are respectively 19 and 3 per cent. of the main tide.

The proportion of the larger evectional tide (ν_2) to the main tide is much larger than it has ever been hitherto, being 11 per cent.; during the other years it ranged from 5 to 8 per cent., while by theory it is less than 4 per cent. The smaller evectional tide (λ_2) is 5 per cent. of the main tide, the other values are from 3 to 6 per cent., and theoretically it is insignificant.

The lunar elliptic tide of the second order ($_2N_2$) is as much under its theoretical value, 0·026, as it was over it last year.

The values of the variational tide (μ_2) are very accordant in all the five years, and are about 3½ times greater than the theoretical value.

With regard to the diurnal tides, their values are very consistent throughout the five years' observations; the proportions of the three principal tides (K_1, O_1 and P_1) are 12, 7 and 4 per cent. of the main tide, and agree with those found at Rangoon and Amherst, while theoretically they should be 58, 42 and 19.

Of the overtides, the lunar (M_4) is the most important: it is 23 per cent. of the main tide; in former years the proportion was somewhat greater, but the several values of this tide are very consistent; at Rangoon this tide is only 8 per cent. of the main tide.

The values of the compound tides are very similar to those obtained last year, the greatest difference is in the quarter diurnal, $(M_2 N)_4$, being about 2 per cent. greater.

Regarding the long period tides, the values deduced for all of them are smaller than last year's. The lunar monthly tide is 9 per cent. of the main tide, which is double the theoretical proportion.

The lunar fortnightly tide is 6 per cent. of the main tide; in former years it ranged from 7 to 10 per cent., but the mean of all the values gives a value nearly corresponding to the theoretical proportion, which is 8½ per cent. of the main tide.

The luni-solar fortnightly tide is 27 per cent. of the main tide; in the other years it was even larger, namely, from 28 to 31 per cent., while by theory this tide is insignificant: only at one other port (Kidderpore) this tide bears such a large proportion to the main tide, where it is about 24 per cent. The values of its epoch are very accordant in the five years' observations which have been deduced.

The solar annual tide is 52 per cent. of the main tide, its other values are from 63 to 68 per cent. Its time of maximum is this year the 12th August, about eight days earlier than last year, but agrees with that of the first year.

The solar semi-annual tide is 13 per cent. of the main tide; the other values are 15 to 18 per cent.; by theory it should be only 4 per cent. of the main tide. The epoch of this tide varies between the 2nd and 19th August.

VALUES OF THE TIDAL CONSTANTS, PORT BLAIR, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=4·689 feet.

S_1	H=	R=	0·051	M_6	R=	0·002	Q_1	R=	0·018	T_2	R=	...
	κ=	ζ=	28°·34		ζ=	47°·12		ζ=	305°·50		ζ=	...
S_2	H=	R=	0·963		H=	0·002		H=	0·022		H=	...
	κ=	ζ=	320°·21		κ=	133°·46		κ=	254°·77		κ=	...
S_4	H=	R=	0·004	M_8	R=	0·002	L_2	R=	0·058	$(MS)_4$	R=	0·008
	κ=	ζ=	126°·03		ζ=	188°·75		ζ=	103°·38		ζ=	318°·37
S_6	H=	R=	0·001		H=	0·001		H=	0·049		H=	0·007
	κ=	ζ=	167°·01		κ=	63°·87		κ=	327°·41		κ=	107°·15
S_8	H=	R=	0·000	O_1	R=	0·126	N_2	R=	0·438	$(_2SM)_2$	R=	0·023
	κ=	ζ=	277° 60		ζ=	92°·84		ζ=	22°·97		ζ=	118°·83
					H=	0·155		H=	0·423		H=	0·022
					κ=	300°·18		κ=	273°·67		κ=	330°·05

Short Period Tides—contd.

A_0—4,689 feet.

M_1	R=	0·024	K_1	R=	0·369	λ_2	R=	0·090	$2N_2$	R=	0·097
	ζ=	233°·94		ζ=	30°·15		ζ=	253°·53		ζ=	289°·27
	H=	0·028		H=	0·417		H=	0·087		H=	0·094
	κ=	288°·03		κ=	330°·20		κ=	175°·94		κ=	281°·89
M_2	R=	2·103	K_2	R=	0·135	ν_2	R=	0·186	$(M_2N)_4$	R=	0·113
	ζ=	133°·24		ζ=	218°·93		ζ=	102°·40		ζ=	57°·48
	H=	2·029		H=	0·179		H=	0·179		H=	0·105
	κ=	282°·02		κ=	278°·59		κ=	297°·56		κ=	96°·96
M_3	R=	0·005	P_1	R=	0·176	μ_2	R=	0·130	$(M_2K_1)_3$	R=	0·024
	ζ=	164°·36		ζ=	256°·76		ζ=	342°·57		ζ=	327°·79
	H=	0·005		H=	0·176		H=	0·121		H=	0·026
	κ=	27°·53		κ=	319°·02		κ=	280°·13		κ=	56°·62
M_4	R=	0·018	J_1	R=	0·028	R_2	R=	...	$(2M_2K_1)_3$	R=	0·004
	ζ=	174°·75		ζ=	105°·80		ζ=	...		ζ=	168°·37
	H=	0·017		H=	0·033		H=	...		H=	0·004
	κ=	112°·31		κ=	305°·32		κ=	...		κ=	165°·88

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·001	231°·26	0·001	129°·34
„ Fortnightly „	0·023	117·88	0·036	31·97
Luni-Solar „ „	0·019	166·48	0·018	17·70
Solar-Annual „	0·165	134·74	0·165	162·47
„ Semi-Annual „	0·157	120·78	0·157	176·25

The value of the mean level of the sea (A_0) is 4·689 feet above the zero of the gauge, or 0·03 foot lower than the mean of the three preceding years, and $\frac{1}{10}$th of a foot lower than that derived in 1880-81.

The amplitudes and epochs of the main lunar and solar tides (M_2 and S_2) agree well with the values obtained in former years, and the proportion of the main solar (S_2) to the main lunar (M_2) is just 1 per cent. greater than the theoretical proportion 0·465.

The luni-solar semi-diurnal tide (K_2) is 9 per cent. of the main tide, or 4 per cent. less than it should be; for the other four years of observations, values slightly larger than the theoretical were obtained. The values of the epoch of this tide for the first four years were very consistent, but this year's value differs from the mean of them by 33°, or 1 hour and 6 minutes in time.

The larger lunar elliptic tide (N_2) agrees in its proportion to the main tide, with all the former values, and is very close to the theoretical proportion, while the smaller elliptic tide (L_2) is 0·024 of the main tide, which is only half of the value derived for it last year and in 1881-82; the proportions in the other two years were about the same as they are now, and approach the theoretical value, 0·028.

The two evectional tides (ν_2 and λ_2) are 9 and 4 per cent. of the main tide respectively; the value of the larger tide (ν_2) in the first two years was 7 per cent., in 1882-83 it was nearly the theoretical proportion 0·038, and last year it was only 1 per cent. of the main tide: the values of the smaller tide (λ_2) are more accordant, as they are from 2 to 4 per cent., but by theory this tide is very small.

The lunar elliptic tide of the second order ($_2N_2$) is about twice as large as it should be, last year it was 2 per cent. of the main tide, which is nearly the theoretical proportion.

The variational tide (μ_2) is 6 per cent. of the main tide, the other values are about 4 per cent., and by theory this tide should be about 2½ per cent.

Regarding the diurnal tides, the values obtained for them this year agree with those obtained in the former years. The three important ones are (K_1, O_1 and P_1), and they are 21, 8 and 9 per cent. of the main tide, while their theoretical values are 58, 42 and 19 per cent.; their epochs are well determined.

The overtides as hitherto are all insignificant.

Of the compound tides, the quarter diurnal (M_2 N) calls for remark; it is 5 per cent. of the main tide, while last year it was under 2 per cent. and its theoretical proportion is 4 per cent. of the main tide.

Of the long period tides, the proportions of the lunar monthly, the lunar fortnightly and the luni-solar fortnightly to the main tide, as hitherto, are very small.

The solar annual tide is this year 8 per cent. of the main tide, the four previous values of this tide are 3, 11, 13 and 15 per cent. of the main tide. Its epoch this year is identical with that obtained in 1880-81, but the several values are not consistent, giving a difference of 47°; its time of maximum seems to vary between the 1st August and 16th September.

The solar semi-annual tide agrees exactly in its proportion to the main tide with last year's value, and fairly well with the others, but it is about double the theoretical value. Its epoch also corresponds with that found last year, and its times of maxima remain about the 18th June and 18th December.

Extract from Report by Major W. J. HEAVISIDE, R.E., *Deputy Superintendent, in charge Astronomical Parties Nos. 1 and 2,—dated 13th January 1886.*

The results of the observations given in the table below show northerly attraction of the plumb line at Rámuápur and Jarúra, southerly attraction at the last five stations and scarcely any attraction at Nimkár. The attraction at Rámuápur is very large but tends to bear out General Walker's remark in the Report for 1867-68, that the northerly attraction of the Himalayas is more fully compensated in the western than on the eastern plains. Thus we can refer to four stations nearly in the plains at which astronomical latitudes have been determined and all pretty nearly equally distant from the Himalayas:—

Sháhpur near the meridian of	75°	showing no attraction.			
Isanpur	„	„	76	„	3·9″ of northerly attraction.
Kaliána	„	„	78	„	5·2 „ „
Rámuápur between	„ 80 and 81		„		11·0 „ „

With the exception of an insignificant belt of rather high ground between Rámuápur and Jarúra, the country from Rámuápur to Pavia appears perfectly flat, broken only by an occasional deep and wide river bed, though the eye in search of visible causes for a deflection of the plumb line is occasionally led astray by a mound which generally turns out to be an old brick kiln, and under these circumstances the southerly attraction shewn at Etora, Dewarsán and Kánákhera is unaccounted for. Pavia is on a small isolated rocky hill, but the Latitude station was in the plain due west of the hill. There are, however, large masses of hill, ranging from 1,100 to 1,300 feet in height, about 30 miles to the south. Potenda is on a high wide ridge with considerable masses of hill, about 10 miles distant from the station, both to the north and south with an apparent preponderance of matter to the south. The results exhibited in the Table may, I venture to think, be considered good. The probable errors are small for a first season's work, and the (N—S) equation no larger than was anticipated. But when the results come to be sifted, some unpleasant features are revealed. The dislevelment of the instrument as shewn by the two levels, is subject to large discrepancies similar to those noticed by Major-General Campbell in his Report for 1871-72, which, he considered, were due to the effects of changes of temperature on the cradle carrying the levels. Colonel Herschel in his Report for 1870-71 refers to instability evidenced by the different indications of the level, and in the manuscript Volume for 1871-72 refers to abrupt changes in the instrumental adjustments, such as I have also met with, and he estimates these at $\frac{2}{10}$ths of a second. With a view to obtain some guide to the magnitude of these discrepancies as affecting the final results from my observations, I have had results deduced for each station, using only one level, and find that the effect on the resulting latitude is to make the final results at Rámuápur and Jarúra, respectively, 0·16″ and 0·24″ in defect of the results obtained by using the two levels. At the other stations the effect is small, not larger than is to be expected from the probable errors of the results, and I think that the large differences at Rámuápur and at Jarúra may be chiefly due to the use of level No. 3, which is certainly not satisfactory, showing a tendency in the bubble when tested to settle at certain points of its curve. Moreover, the temperatures at Rámuápur and at Jarúra were considerably lower than at any other stations, and though attempts were made to obtain scale-values of the levels at these low temperatures, the values obtained were not satisfactory, more especially with level No. 3, owing perhaps to the want of proper appliances for testing them. I think that scale-values for levels should certainly be obtained at the highest and lowest temperatures at which they are used in observing.

Results of the Latitude Observations taken by Major W. J. HEAVISIDE, R.E., *with Strange's Zenith Sector No. 2, Season 1884-85.*

Station.		North Stars. Number of Stars observed.	Number of observations.	Mean Zenith Distance.	Extreme Zenith Distance.	South Stars. Number of Stars observed.	Number of observation.	Mean Zenith Distance.	Extreme Zenith Distance.	Mean Resulting Latitude by North and South Stars combined. λ_o	(N—S).	$(\lambda_o - \lambda_c)$.	Approximate Longitudes.
				° ′	° ′			° ′	° ′	° ′ ″ ″	″	″	° ′
Rámuápur	T. S.	14	78	6 34	12 43	14	79	6 19	13 15	28 22 0″04±0″07	−0·79	−11·00	80 31
Jarúra	T. S.	13	59	6 44	12 53	13	62	6 58	12 39	27 59 50″06±0″07	−1·91	−5·88	80 31
Nimkár	T. S.	14	60	4 17	11 0	14	59	4 4	8 51	27 21 8″06±0″07	−0·52	−0·03	80 32
Etora	T. S.	14	50	4 27	10 4	15	49	4 23	9 57	26 54 22″60±0″07	−0·70	+4·75	80 42
Dewarsán	T. S.	17	55	4 42	12 16	16	57	4 42	9 19	26 15 58″32±0″06	−0·35	+5·43	80 21
Kánákhera	T. S.	16	68	5 43	14 3	16	65	5 26	14 42	25 51 25″82±0″06	−0·05	+4·87	80 28
Pavia	H. S.	18	71	6 4	14 27	17	63	6 17	14 18	25 27 21″01±0″06	−0·11	+3·62	80 47
Potenda	P. S.	15	55	5 50	12 23	16	60	5 39	12 2	24 37 24″56±0″06	−0·09	+1·52	81 0

NOTE.—The column headed (N—S) exhibits the mean difference of latitude between Stars north and south of the Zenith. The column headed $(\lambda_o - \lambda_c)$ exhibits the difference between the observed astronomical latitude λ_o and the geodetic latitude λ_c as computed from the origin of the Triangulation. The negative sign shown northerly, and the positive sign southerly, attraction of the plumb line.

xtract from the Narrative Report of MAJOR G. STRAHAN, R.E., *Deputy Superintendent, in charge No. 2 Astronomical Party, for season 1885-86.*

I reached Agra on my return from furlough on the 6th November 1885, and proceeded at once to take over charge of No. 2 Astronomical Party from Major Heaviside.

The transit instruments belonging to the two Astronomical Parties had been sent out from England a short time before my arrival in Agra, at which place they had been set up for the purpose of examining the repairs and improvements that had been made under my superintendence in England, and also for the purpose of instructing Lieutenant Burrard in the method of determining electro-telegraphic differences of longitude, as it had been decided that he should succeed Major Heaviside in charge of No. 1 Party when the latter officer proceeded on furlough.

The personal equation between Major Heaviside and myself was measured on the 11th, 12th and 13th November, and all necessary preparations having been made, Major Heaviside and Lieutenant Burrard left Agra on 18th November to proceed to Mooltan; the first arc on the programme of the season being Agra-Mooltan. This was begun on November 23rd, and, owing to the prevalence of favorable weather, was completed in six consecutive nights. The work of the 27th was carried on through the superb display of meteors which occurred on that night.

The next arc to be measured being Deesa-Mooltan, I proceeded at once to the former station, where I arrived on December 4th, but owing to some delays on the Rajputana Railway, my instruments were not ready for beginning the work till December 7th. The old pillars, which had been used by Major Heaviside in 1881, were found in good order and were utilized for the current season. Seven nights were required for this arc, and by December 17th, I had again reached Agra to commence the arc Agra-Amritsar. It had been directed that on one arc of the season there should be an interchange of observers after half the work was finished, their instruments being left standing. The arc Agra-Amritsar was the one selected for this experiment. Accordingly, after four nights had been completed, I proceeded to Amritsar, and Major Heaviside to Agra, in which position four more nights' work was added, he using my telescope, clock and chronograph, and I using his. This was the first arc on which Lieutenant Burrard took an active part in the work, the fourth and eighth nights were both done by him at Amritsar. I measured a personal equation with him at Amritsar on the 30th and 31st December. The arc Amritsar-Mooltan was next on the list. This was begun on January 5th and completed on January 19th, the delay being caused by cloudy weather at Amritsar; all three observers took part in the measurement of this arc: the nights of the 7th, 10th, 16th, and 24th were utilized in determining the personal equation between Major Heaviside and Lieutenant Burrard at Amritsar.

Mooltan-Kurrachee was the next arc undertaken. The latter station was the one at which my apparatus was erected, and of the six nights of observations four were worked by Major Heaviside and two by myself at Kurrachee, Lieutenant Burrard officiating at Mooltan throughout. On February 1st and 2nd, I again measured a personal equation with Major Heaviside, after which he proceeded on furlough and Lieutenant Burrard was left in sole charge of No. 1 Party.

The next arc Peshawar-Mooltan was commenced on February 9th and completed on February 18th with some difficulty, owing to the gradual approach of bad weather. On the succeeding arc Amritsar-Peshawar, the weather was the worst that has ever been experienced since the Longitude work was first begun, and owing to this, and partly also to an attack of dysentery, by which I was prevented from working for more than a week, no less than 26 days were occupied on this one arc.

On the 25th and 26th March, while my equipment was moving to Dehra Dun, I again measured a personal equation with Lieutenant Burrard at Amritsar. Between the 1st and 12th April the arc Dehra Dun-Amritsar was finished, and between 20th and 25th April the last arc of the season, Dehra Dun-Agra, was successfully measured. Lieutenant Burrard then brought his equipment to Dehra, and the observations were taken in the experimental arc; after which the party returned to recess quarters at Mussooree and opened office there on 17th May.

There were but few novelties in the procedure during the season. On the first three arcs, *viz.*, Agra-Mooltan, Deesa-Mooltan, Agra-Amritsar, the telescope at the eastern station had its pivots reversed in the middle of each night's work, *i.e.*, between the 2nd and 3rd groups of stars, and that at the western station at the close of each night's observations. Subsequently, it was decided that the uncertainty of the telescope taking up at once a permanently stable position immediately after reversal more than counterbalanced the advantages aimed at, *viz.*, the systematic variation as far as possible of the circumstances under which the observations were made. This method was therefore abandoned, and on the remaining arcs the telescope at the eastern station was reversed after the 1st, 3rd and 5th nights, and that at the western station after the 2nd, 4th and 6th.

The method known in this department as "observations of transits with local clocks combined by clock comparisons," which had been employed in previous years under the impression that it was a valuable and independent check on that called "observations of transit at both stations with the same clock," was abandoned this season, partly because the check afforded by it is more apparent than real, as instrumental errors are similarly involved in both, and partly because it was considered that the length of programme

necessary for carrying out both methods somewhat overtaxed the observer's endurance, and it is universally admitted among scientific men that bodily or mental fatigue is fatal to accuracy of observation.

There was no novelty in the remaining arcs, and the customary procedure was carried out in all of them. After their completion, the experimental arc alluded to above, was undertaken at Dehra Dun, on which all corrections for collimation and level were made in the usual manner, but the deviation correction was obtained by the use of a meridian mark fixed on the Mussooree hills for this purpose, instead of by circumpolar stars, as usually practised. The method of obtaining its true position and other details, which may be of some interest for future observers, are therefore given below.

The observations for personal equation appear to be somewhat discordant this season for some unknown reason, and it was at first sight a little difficult, where all three observers are concerned, so to adjust their relative equations that that subsisting between the 1st and 3rd should equal the difference of those between the 1st and 2nd and the 2nd and 3rd; in fact, the observations were somewhat contradictory, and as this was the first season in which Lieutenant Burrard had made any observations of the kind, I was at first inclined to attribute the discordance to a fluctuating value of his personality. On further examination of the matter however, his transit observations seemed to be so good that I hesitated at this solution of the difficulty, and determined on making a graphic representation of the data from which the personal equations are determined, and on getting the values of the equation for each arc by interpolation from the curves so obtained. I believe this method to be a very sound one, and have appended the equation curves to this report. They need but little explanation. The divisions proceeding horizontally represent two days each, and vertically, hundredths of a second of time. The dates on which the observations for personal equation were made are duly entered, and the corresponding values of the equation between the observers plotted off from the straight line to which my name is attached. I have selected this line as a basis, as I am the only one of the three observers who worked throughout the whole season and took part in all the arcs. The thick black lines at the bottom and top of the page represent the dates during which the measurement of each arc was carried on, and the dotted lines through the equation curves are drawn at the middle of each arc, and give the interpolated value of the personal equation at once by actual measurement. North and south stars are kept separate both in this process and in the reduction of transits. In former years it was the custom for each observer to take each night some few stars that passed sufficiently close to the zenith of both stations under both aspects, *i.e.*, that the passage over the first ten wires was noted by the observer with his face towards the south, and the last ten with his face towards the north or *vice versâ*. This procedure was omitted on the last four arcs of the present season for two reasons: first, because I had come to the conclusion that the equation thus deduced, which has been hitherto called the absolute N—S equation, is merely a matter of curiosity; and secondly, because the hurry involved in getting round the instrument, to be in time for the last ten wires, seems to produce some uncertainty in the observations.

The position of Dehra Dun affords most unusual opportunities for the use of a permanent meridian mark, situated as it is, due south of a range of hills rising 5,000 feet above it, and at a distance at which the solar focus of the largest telescopes we employ can be safely used. The use of such a mark is a very great saving of time in observing and computing transits; it avoids all chance of observing wrong circumpolar stars or of losing them by the intervention of clouds, and also the necessity of so selecting the time of observation of transits as to fit in with a previously-chosen circumpolar pair. The usual difficulty of obtaining a suitable site at a sufficient distance is fortunately absent in the present case.

A rough guess at its probable position on the hill having been made, an assistant was sent there with a heliotrope and directed to show a steady light on the Dehra Dun observatory. Two heliotropes, one on the east and one on the west side of the observatory, about 70 or 80 yards apart, were then adjusted on him; after a preconcerted interval, the one on the side towards which it was wished he should proceed was flashed a certain number of times corresponding to the estimated number of yards he was to move. Having paced out or estimated the distance, he proceeded to show his heliotrope again, which was then well within the range of the micrometer of a previously adjusted transit telescope. A repetition of the process established the true position of the mark within a fraction of a yard. A lamp was shown at night from the spot thus fixed, and its distance from the true meridian obtained by a set of observations to the pole star which I will now describe.

The principle underlying the method is that with a knowledge of the true sidereal time we can compute the distance of Polaris from the meridian, and therefore if we note the reading of the micrometer at a certain time when Polaris is passing the centre (or any known) wire and then take a reading of the micrometer when the same wire intersects our approximate meridian mark, we obviously have data for determining its position. Several things however have to be attended to in actual practice, the most important perhaps being that, as a series of observations is necessary for accuracy, it would be unsafe to assume the stability of the line of collimation during the whole time they are being made. The programme I arranged was as follows:—

(1) Observations for collimation,
(2) „ for level,
(3) Transits of two Nautical Almanac Stars, for time about 45 minutes before the culmination of Polaris, followed by—

PERSONAL EQUATION DIAGRAM

Deduced Personal Equations for the several Area.

| | | |

(4) Micrometer reading of North Collimator.
" " Meridian lamp.
" " Polaris with corresponding chronometer time.
" " South Collimator.
" " South Collimator.
" " Polaris with chronometer time.
" " Meridian lamp.
" " North Collimator.

This was repeated again and again until Polaris was about as far past culmination as it had been before it when the series was begun.

The observations were then completed by transits of two more Nautical Almanac stars for time, and lastly, by determinations of level and collimation. The reductions, with an explanation of them, will be found among the other computations submitted this season, and need not be further dwelt upon here; suffice it to say that the result is that the true position for the mark was found to be 20·1 inches westward of the assumed one with a probable error of ± 1·3 inches. On the site thus obtained, a meridian mark in the shape of a wedge pointing upwards, about 6 feet broad at base and 10 feet high, has been built of stone for future use.

The recess work has been unusually heavy owing to the large number of arcs measured during the season, and in consequence of my having the Andaman Party on my hands as well as the astronomical work. Having also undertaken the preparation of the new Longitude Volume for the press, I have had but little time to give to the details of the computations, which therefore devolved chiefly upon Lieutenant Burrard.

There has been no novelty in this part of the work needing much explanation in detail.

An approximate method of reduction of transits to the centre wire, which had been previously employed with a view to saving labor, was abandoned, as not being sufficiently exact, and the star constants A, B, C, for correcting transits for azimuth, level and collimation, were computed for each star, instead of being taken from tables. The saving of labor by the latter method was practically *nil*, as in order to get a true value a good deal of interpolation was necessary, so that the computation of the constants for each star separately appeared to be little, if at all, more laborious. The mass of figures required for the reduction of the observations is very large, but I am glad to be able to report that with the assistance of two computers kindly lent by Mr. Cole, they have been fully completed and no arrears of any kind remain.

A question has been occasionally raised amongst the various officers hitherto employed on the Electro-telegraphic Longitude work as to the desirability of establishing some criterion for the rejection of abnormally discordant wires in the observation of transits. The subject was again brought to my notice by Lieutenant Burrard, R.E., in a conversation at Amritsar, and I determined to investigate the matter further, and endeavoured to form, on the basis of Professor Peirce's criterion, a somewhat similar test applicable to the Longitude work. For this purpose I undertook an analysis of personal errors of star transits on the arc Agra-Mooltan. This arc was chosen for discussion on account of its being a remarkably complete one, only three stars being wholly missed on the six nights' work, and nearly every star having been observed on the full complement of wires, *viz.*, 11. The words "personal error" are used above in contradistinction to those errors which depend on want of adjustment or defects in the instruments, such as errors of collimation, level, deviation, irregular clock rate, &c., which are not here considered, but merely those caused by the failure of the observer to note the passage of a star over every wire in an exactly similar way; or, as it may be expressed, by a variation in the observer's personality. Every wire observed has been used in the discussion whether apparently wide of the mean or not, as one of the principal objects of the investigation is to discover, with the assistance of Peirce's criterion, a limiting error beyond which observations must be rejected. It is obviously impossible to apply Peirce's criterion *in extenso* to every star observed during a season's work, owing to the vast amount of computation required, and the small value of the ends attainable, but a table may be advantageously formed on the results of one arc from which, by inspection, the limiting errors may be found with quite sufficient accuracy to determine the rejection of abnormal intersections for all arcs. This table is No. II and sufficiently explains itself.

The reduced time of passage of a star over each wire was first subtracted from that over the mean wire to form the residuals (v). Table No. I contains for each star on each night three quantities, *viz.*, $\Sigma(v^2)$ = the sum of the squares of the residuals, m = number of wires observed, and $\varepsilon = \sqrt{\frac{\Sigma(v^2)}{m-1}}$ = the mean error = 1·48 × probable error.

Chauvenet's notation is retained throughout.

A certain number of zenith stars were observed on 10 wires North aspect and 10 wires South aspect. These have been kept separate in the discussion. The whole series of stars is arranged in order of Declination for convenience of reference. It might have been supposed *a priori* that the errors would vary as the secant of the star's declination, but this has not been found to be the case in practice, and so no regular law has been deduced.

The observations themselves have been considered as furnishing the best values of ε, as magnitude and other causes may combine to mask any law depending on the secant of declination.

TABLE

FIRST PART.—*South Stars—i.e.,*

Star.	1678	1508	μ Erid	α Ceti	o Tauri	1068	Daily means.	1087	1591	1485	δ Arietis	Daily means.
Declination .	° ′ −0 58	° ′ +2 19	° ′ −3 28	° ′ +3 38	° ′ +8 38	° ′ +9 20	° ° 0 to 10	° ′ +12 33	° ′ +15 27	° ′ +15 42	° ′ +19 18	° ° 10 to 20
November, 23 $\Sigma(v^2)$	·0151	·0203	·0307	·0191	·0264	·0329	·1445	·0197	·0614	·0490	·0098	·1399
November, 23 m	11	11	11	11	10	11	65	11	11	11	11	44
November, 23 ε	·039	·045	·055	·044	·054	·057	·047	·044	·078	·070	·031	·056
November, 24. $\Sigma(v^2)$	·0175	·0131	·0119	·0339	·0168	·0841	·1773	·0265	·0182	·0319	·0368	·1134
November, 24. m	11	11	11	11	11	11	66	11	11	11	11	44
November, 24. ε	·042	·036	·035	·058	·041	·092	·052	·051	·043	·056	·061	·051
November, 25. $\Sigma(v^2)$	·0184	·0429	·0195	·0385	·0146	·0276	·1615	·0228	·0120	·0257	·0207	·0812
November, 25. m	11	11	11	11	11	11	66	11	8	11	11	41
November, 25. ε	·043	·066	·044	·062	·038	·053	·049	·048	·041	·051	·045	·044
November, 26. $\Sigma(v^2)$	·0221	·0349	·0176	·0156	·0137	·0254	·1293	·0176	·0200	·0211	·0243	·0830
November, 26. m	11	11	11	11	11	10	65	11	11	11	11	44
November, 26. ε	·047	·059	·042	·039	·037	·053	·045	·042	·045	·046	·049	·043
November, 27. $\Sigma v(^2)$	·0227	·0465	·0143	·0176	·0554	·0149	·1714	·0234	·0551	·0229	·0414	·1428
November, 27. m	11	11	11	11	11	11	66	10	11	11	11	43
November, 27. ε	·048	·072	·038	·042	·074	·039	·051	·051	·074	·048	·064	·058
November, 28. $\Sigma(v^2)$	·0212	·0209	·0133	·0190	·0547	·0395	·1686	·0108	·0297	·0177	·0122	·0704
November, 28. m	11	11	11	11	11	11	66	11	11	11	11	44
November, 28. ε	·046	·046	·036	·044	·074	·063	·051	·033	·054	·042	·035	·040
Mean of 6 days. $\Sigma(v^2)$	·1170	·1786	·1073	·1437	·1816	·2244	·9526	·1208	·1964	·1683	·1452	·6307
Mean of 6 days. m	66	66	66	66	65	65	394	65	63	66	66	260
Mean of 6 days. ε	·042	·052	·040	·047	·053	·059	·049	·043	·056	·051	·048	·049

No. 1.

Stars observed South of the Zenith.

1637	η Tauri	957	1497	1577	1444	974	1025	1658	Daily means.	Means for all South Stars.	
° ′ 21 59	° ′ 23 45	° ′ 24 48	° ′ 27 42	° ′ 28 7	° ′ 28 23	° ′ 28 38	° ′ 28 38	° ′ 28 50	° 20 to 30		
·0249	·0323	·0353	·0358	·0247	·0231	·0446	·0272	·0345	·2824	·5668	Probable Error = ·6745 × ε
11.	11	11	10	10	10	10	10	10	93	202	
·050	·057	·059	·063	·052	·050	·070	·055	·062	·055	·053	
·0346	·0462	·0242	·0560	·0199	·0343	·0490	·0146	·0227	·3015	·5922	
11	11	11	10	10	10	10	7	10	90	200	
·059	·068	·049	·079	·047	·062	·074	·046	·050	·058	·054	
·0109	·0307	·0589	·0568	·0438	·0379	·0451	·0106	·0337	·3284	·5711	
10	11	11	10	10	10	10	10	10	92	199	
·033	·055	·077	·111	·070	·065	·070	·034	·061	·060	·054	
·0350	·0154	·0405	·1106	·0491	·0275	·1025	·0646	·0255	·4707	·6830	
11	10	11	6	10	10	10	10	10	88	197	
·059	·041	·064	·036	·074	·055	·107	·085	·053	·073	·059	
·0818	·0507	·0314	·0078	...	·0369	·0472	·0608	·0285	·3454	·6596	
11	11	11	10	...	10	9	8	10	80	189	
·090	·071	·056	·050	...	·064	·072	·087	·056	·066	·059	
·0205	·0242	·0153	·0222	·0638	·0133	·0416	·0154	·1322	·3482	·5872	
11	11	11	10	10	10	10	10	10	93	203	
·045	·049	·039	·079	·084	·038	·068	·041	·121	·061	·054	
·2077	·1995	·2056	·2892	·2013	·1730	·3300	·1932	·2771	2·0766	3·6599	
65	65	66	56	50	60	59	55	60	536	1190	
·057	·055	·056	·072	·064	·054	·075	·059	·068	·062	·055	

TABLE

SECOND PART.—*Stars observed*

Star.		1497	1577	1444	974	1025	1658	Daily means.	1207	1614	1452	1175	ι Aurigæ.
Declination .		° ′ 27 42	° ′ 28 7	° ′ 28 23	° ′ 28 38	° ′ 28 38	° ′ 28 50	° ° 20 to 30	° ′ 31 33	° ′ 32 33	° ′ 32 39	° ′ 32 45	° ′ 32 59
November, 23	$\Sigma(v^2) =$	·0393	·0486	·0254	·0449	·0354	·0152	·2088	·0657	·0910	·0417	·0276	·0313
	$m =$	10	10	10	10	10	10	60	11	11	11	11	9
	$\varepsilon =$	·066	·073	·053	·071	·063	·041	·067	·081	·095	·065	·052	·059
November, 24	$\Sigma(v^2) =$	·0429	·0203	·0788	·0409	·0096	·0716	·2641	·0194	·0472	·1316	·0393	·0209
	$m =$	10	10	10	10	8	10	58	11	11	11	11	11
	$\varepsilon =$	·069	·047	·094	·067	·035	·089	·068	·044	·069	·114	·063	·046
November, 25	$\Sigma(v^2) =$	·0991	·0618	·0222	·0243	·0703	·0695	·3472	·0806	·0294	·0515	·0410	·0640
	$m =$	10	10	10	9	10	10	59	11	11	11	11	11
	$\varepsilon =$	·105	·083	·050	·052	·088	·088	·078	·090	·054	·072	·064	·080
November, 26	$\Sigma(v^2) =$	·0208	·0732	·0669	·0796	·0369	·0780	·3554	·0355	·0219	·0429	·0258	·0566
	$m =$	10	10	10	10	10	9	59	11	8	11	11	11
	$\varepsilon =$	·048	·090	·086	·094	·064	·098	·078	·060	·052	·065	·051	·075
November, 27	$\Sigma(v^2) =$	·0139	...	·0505	·0182	·0400	·0193	·1419	·0377	·0257	·0552	·0767	·023
	$m =$	9	...	10	10	10	10	49	10	11	10	11	11
	$\varepsilon =$	·040	...	·075	·045	·067	·046	·054	·065	·050	·078	·087	·048
November, 28	$\Sigma(v^2) =$	·0447	·0065	·0580	·0473	·0141	·0228	·1934	·0411	·0483	·0559	·0968	·0430
	$m =$	10	6	10	10	10	10	56	10	11	10	11	11
	$\varepsilon =$	·070	·033	·080	·072	·040	·050	·059	·067	·069	·079	·098	·065
Mean of 6 days	$\Sigma(v^2) =$	·2607	·2104	·3018	·2552	·2063	·2764	1·5108	·2800	·2635	·3788	·3072	·2390
	$m =$	59	46	60	59	58	59	341	64	63	64	66	64
	$\varepsilon =$	·067	·068	·071	·066	·060	·068	·067	·066	·065	·077	·068	·061

No. 1—*continued.*

North of the Zenith.

1627	1017	1123	1530	1602	1219	Daily means.	963	993	Daily means.	Means for all North Stars.	General Mean.	
° ′	° ′	° ′	° ′	° ′	° ′	° °	° ′	° ′	° °			
33 15	33 48	37 13	37 43	38 21	39 41	30 to 40	40 31	42 5	40 to 43			
·1043	·0415	·0412	·0228	·1020	·0469	·6160	·1054	·0458	·1512	·9760	1·5428	Probable Error = ·6745 × ε
11	11	11	11	11	11	119	11	11	22	201	403	
·102	·064	·064	·048	·101	·068	·072	·103	·068	·085	·070	·062	
·0631	...	·1059	·0458	·0203	·0348	·5283	·0340	·0264	·0604	·8528	1·4450	
11	...	11	11	11	11	110	11	11	22	190	390	
·079	...	·103	·068	·045	·059	·070	·058	·051	·054	·067	·061	
·0323	·0908	·0317	·0247	·0663	·0986	·6109	·0860	·0582	·1442	1·1023	1·6734	
11	11	11	11	11	11	121	11	11	22	202	401	
·057	·095	·056	·050	·081	·099	·071	·093	·076	·085	·074	·065	
·1529	·0727	·0927	·0501	·1017	·0382	·6910	·0611	·0536	·1147	1·1611	1·8441	
11	11	11	11	11	11	118	11	11	22	199	396	
·123	·085	·096	·071	·100	·062	·077	·078	·073	·074	·076	·067	
·0251	·0408	·0445	·0459	·0648	·0684	·5080	·0719	·0715	·1434	·7933	1·4529	
11	11	11	11	11	11	119	10	11	21	189	378	
·050	·064	·066	·068	·080	·083	·066	·089	·084	·085	·065	·062	
·0411	·0786	·0366	·0539	·0825	·0433	·6211	·0496	·0163	·0659	·8804	1·4676	
11	11	11	11	11	11	119	11	11	22	197	400	
·064	·089	·060	·073	·091	·066	·073	·070	·040	·056	·067	·061	
·4188	·3244	·3526	·2432	·4376	·3302	3·5753	·4080	·2718	·6798	5·7659	9·4258	Probable Error of single wire ± ·0426
66	55	66	66	66	66	706	65	66	131	1178	2368	
·080	·077	·073	·061	·081	·071	·071	·079	·064	·072	·070	·063	

Table No. I is so arranged as to show at the foot of each column $\Sigma(v^2)$, m and ϵ for each star on the mean of the six nights. Means for the sum of the stars on each night are also given, and at the end of the table is the mean result for the whole, and r the probable error of one intersection for the whole arc. The stars have been divided into the following groups according to declination, 0° to 10°, 10° to 20°, 20° to 30°, 30° to 40°, and 40° to 43° for which ϵ is found to be ·049, ·049, ·065, ·071 and ·072. From these values, with the aid of Table X in Chauvenet's Astronomy, the following table is compiled.

TABLE II.—*Criterion for rejecting doubtful observations.*

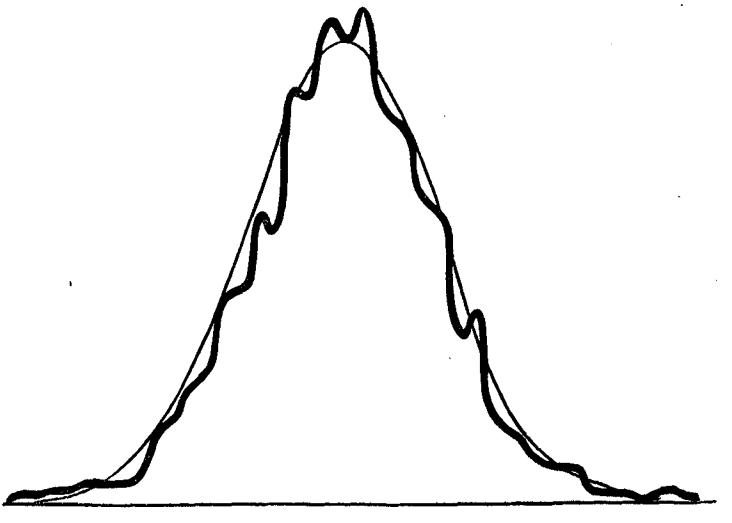
Number of wires observed.	0° to 10°	10° to 20°	20° to 30°	30° to 40°	40° to 43°
5	·11	·11	·15	·16	·16
6	·13	·13	·17	·18	·19
7	·14	·14	·19	·20	·21
8	·15	·15	·20	·22	·22
9	·16	·16	·22	·24	·24
10	·17	·17	·23	·25	·25
11	·18	·18	·24	·26	·27

The application of this table rejects only one observation on the present arc Agra-Mooltan.

The probable error of one intersection, r, by the rigorous formula $= \cdot 6745 \sqrt{\frac{\Sigma(v^2)}{m-1}} = \cdot 0426$;

and by the approximate formula (Chauvenet Vol. II, p. 497) $r = \cdot 8453 \frac{\Sigma v}{\sqrt{m\ (m-1)}} = \cdot 0420$.

Advantage was taken of the numbers collected together in Table I to draw out a curve of which the abscissa at any point represents the magnitude of any error and the ordinate represents its relative frequency, and to compare it with the probability curve, with which it should theoretically coincide.



The two curves are shown in the diagram, the thin line being the probability curve computed with the help of Chauvenet's Table IX A., and the thick line being plotted from the actual errors, 2368 in number.

The agreement between the two is striking. It must, however, be remarked that these errors are not deduced under precisely the same circumstances as contemplated by Chauvenet. The latter case provides strictly for the errors of measurement of one and the same quantity, the former for a number of groups of measurements of similar things under circumstances exactly similar (except so far as declination is concerned). It is much the same thing as if the measurements had all been made on the same quantity, and had then been sub-divided into groups of 10 or 11 in each before the residuals had been determined. The mean of each group being then taken, the residuals are determined by subtracting

each observation from the mean of the group in which it occurs. The numerical agreement of the probability curve with the curve of errors is shown in the following table:—

Between.	Errors by Theory.	Errors Actual.
ε and ε		
0·00 and 0·01	302	314
0·01 „ 0·02	294	310
0·02 „ 0·03	280	278
0·03 „ 0·04	258	260
0·04 „ 0·05	234	225
0·05 „ 0·06	206	192
0·06 „ 0·07	178	172
0·07 „ 0·08	148	141
0·08 „ 0·09	120	120
0·09 „ 0·10	96	93
0·10 „ 0·11	74	67
0·11 „ 0·12	56	52
0·12 „ 0·13	42	40
0·13 „ 0·14	30	27
0·14 „ 0·15	20	17
0·15 „ 0·16	14	18
0·16 „ 0·17	8	13
0·17 „ 0·18	5	8
0·18 „ 0·19	2	7
0·19 „ 0·20	2	5
Over 0·20	1	7

DRAWING OFFICE, CALCUTTA.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILING.

Statement showing the work performed and the progress made from 1st October 1885 to 30th September 1886.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS AND PROGRESS.
General.		In. Mls.	
India. Engraved Map	6	1 = 32	Additions to date, and hills.
Do. Ditto	4	1 = 64	Skeleton Maps: additions and changes in boundaries and railways, &c., to date.
Do. Ditto	2	1 = 80	
Do. Ditto	2	1 = 96	
Do. Railway Feeders	6	1 = 32	Re-drawn for photozincography.
Do. External Trade	1	1 = 80	
Do. Railway Map	6	1 = 32	Showing railways, steam routes, and light-houses.
Do. Canal Map	6	1 = 32	New edition. Published.
Do. Geological	1	1 = 128	For Geological Survey.
Do. Skeleton	6	1 = 32	Showing only principal rivers, towns and mountain ranges.
Do. Ditto	2	1 = 64	Showing districts.
Do. Crop Maps	2	1 = 64	Hand-painted and prepared from data furnished by Revenue and Agricultural Department: 71 copies were prepared and supplied to Revenue and Agricultural Department.
Do. Land Settlement	2	1 = 64	
Do. Revenue Rates	2	1 = 64	
Do. Density of Population	2	1 = 80	Hand-painted in shades of neutral tint for Revenue and Agricultural Department, and Colonial Exhibition (6 copies).
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Do. External Trade	2	1 = 64	Ditto to illustrate external trade and places of registration.
Do. Railway Map	1	1 = 128	Corrected to date.
Skeleton Map of Burma and Assam Frontier.	1	1 = 32	Prepared for the Political Department of India Office.
Skeleton Map of Eastern Afghanistan and Punjab.	1	1 = 32	
Skeleton Map of Baluchistan and Sind Frontier.	1	1 = 32	
Mysore State	1	1 = 16	New compilation from 1″=1 mile, Topographical Surveys. The first edition to be photozincographed, but ultimately to be engraved.
Baluchistan	1	1 = 16	A new compilation. In progress.
Province of Assam	2	1 = 16	Additions in outline and hills.
Rajputana Agency	2	1 = 16	Ditto up to date in outline and hills.
North-West Provinces and Oudh	2	1 = 16	Western sheet completed for engraving.
Central Provinces	1	1 = 32	Drawn on 1″=16 miles for reduction by photozincography to 1″=32 miles.
NORTH-WEST TRANS-FRONTIER.			
Sheets Nos. 29 S. E., 29 S. W., 30 S. W., and 30 N. W.	4	1 = 4	From routes and latest surveys. Published.
Sheet No. 22	1	1 = 8	Despatched to Dehra after completing available information.
Sheets Nos. 22 S. E., 28 S. E., and 27 S. E.	3	1 = 4	Being drawn in uniformity with rest of sheets.
Sheets Nos. $29\frac{N.E.}{1}$, $29\frac{N.E.}{3}$, $29\frac{S.E.}{1}$, $29\frac{S.E.}{2}$, and $30\frac{N.W.}{1}$	5	1 = 2	From recent surveys; in full sheets.
North-East Trans-Frontier Sheet No. 22.	1	1 = 8	From latest surveys by Colonel Woodthorpe.
Kohat Sheet No. 7	1	1 = 1	Drawn for photozincography.
Simla Revision Survey Sheets Nos. 1, 2, 3, 4, 6, 7, 8, 12, and 13.	9	24 = 1	Showing level contours at 50 feet vertical intervals.
Gujarat Survey Sheet No. 184	4	2 = 1	Completed heading, reference and foot-notes.
Cutch Survey Sheets Nos 31, 32, 52, 53, and 70.	5	1 = 1	
Burma Reconnaissance Sheets Nos. 23 N. W., and 23 S. W., N. E. Trans-Frontier.	2	1 = 4	Prepared by Captain Hobday from surveys, routes, reconnaissance and local information. Printed and finished in Drawing Office.
Burma Reconnaissance Sheet No. 1 S. E., Trans-Frontier.	1	1 = 4	
Map of Kathiawar	1	1 = 10	For Political Agent, Kathiawar, for reduction by photozincography to 1″=16 miles.
Map of Suakim	1	1 = 1	Inserted borders, headings and foot-notes.
Chart of Triangulation, Suakim	1	1 = 1	
Outline Map of Dalhousie Sanitarium.	4	10 = 1	Drawn from survey executed in 1870.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

TITLE OF MAP.	Number of Sheets.	Scale. In. Mls.	REMARKS AND PROGRESS.
NORTH-WEST TRANS-FRONTIER—*contd.*			
Map of the World, illustrating the Exports and Imports of India during 1883-84.	1	...	For Revenue and Agricultural Department.
Map of the World, illustrating the Exports and Imports of India during 1884-85.	1	...	
Triangulation Chart of the N. E. Trans-Frontier.	1	1 = 4	Completed border, heading, foot-notes, &c.
Routes from Nushki to the Helmand.	2	1 = 8	Tracings supplied to the Government.
Boundary between Sind and Jodhpore.	1	1 = 4	Ditto to Political Agent, Western Rajputana.
Bangalore City, Cantonment and Environs.	4	12 = 1	Inserted level contours on sheets.
Garo Hills, Lower Assam	1	1 = 2	Additions and corrections for photozincography.
Map of Delhi	6	1 = 1	Prepared for Camp of Exercise, for reduction by photozincography to half scale.
Do. Gurgaon	3	1 = 1	
Do. Karnal	5	1 = 1	
Skeleton Map of Bengal	12	1 = 8	For general use. (Not yet complete) for reduction by photozincography to 1″ = 16 and 1″ = 24 miles.
Sheets of the Atlas of India.			
No. 4 S.E.	1	1 = 3	Being drawn for heliogravure.
„ 6 N.E.	1	1 = 3	Drawn for heliogravure.
„ 12 N.W.	1	1 = 4	Hills in brush for engraving.
„ 14 S.W.	1	1 = 3	Preparing for heliogravure. Hills in brush.
„ 15 N.E.	1	1 = 4	Artistically drawn for photozincography.
„ 15 S.W.	1	1 = 4	Hills in brush for engraving.
„ 19 N.E.	1	1 = 4	Ditto ditto.
„ 23 N.E.	1	1 = 4	Completing outline for engraving.
„ 35 S.W.	1	1 = 4	Hills in brush for engraving.
„ 36 N.W.	1	1 = 4	Completed outline and printing for engraving.
„ 37 S.W.	1	1 = 4	Outline and names for engraving.
„ 38 S.E., S.W.	2	1 = 4	Hills in brush for engraving.
„ 39 S.E.	1	1 = 4	Ditto ditto.
„ 40 N.E.	1	1 = 4	Ditto ditto.
„ 46 full plate	1	1 = 4	Corrected boundaries and inserted new roads.
„ 47 S. W.	1	1 = 4	Prepared border, heading, and foot-notes for photozincography.
„ 48 N. E.	1	1 = 4	Re-writing names on outline print (original lost).
„ 49 S. E.	1	1 = 4	Hills in brush for engraving.
„ 50 S.E., N.W.	2	1 = 4	Additions in outline and names for engraving.
„ 60 N.E., S.E.	2	1 = 4	Ditto ditto ditto
„ 60 N. W., S. E.	2	1 = 4	Hills in brush for engraving.
„ 67 S. W.	1	1 = 4	Additions in outline and names for engraving.
„ 77 N. E., N. W.	1	1 = 4	Hills in brush for engraving.
„ 88 S.E.	1	1 = 4	Ditto ditto.
„ 114 S.E.	1	1 = 4	Additions in outline and names for engraving.
Divisions of Bengal.			
Presidency Division	4	1 = 4	Compiled from latest materials for reduction to 1″ = 8 miles by photozincography.
Bhagalpur	2	1 = 4	Being compiled for reduction to 1″ = 8 miles by photozincography.
Patna	8	1 = 4	
Burdwan	2	1 = 4	
District Maps.			
District Jessore	1	1 = 4	Prepared for lithography from transfers from copper-plates.
Do. Nuddea	1	1 = 4	
Do. Jalpaiguri	1	1 = 4	
Do. Sonthal Pergunnahs	1	1 = 4	
Do. Cachar	1	1 = 4	
Do. 24-Pergunnahs	1	1 = 4	
Do. Nowgong	1	1 = 4	
Do. Sibsagar	1	1 = 4	
Do. Sylhet	1	1 = 4	Corrected to date.
Do. Ghazipur	1	1 = 4	Touched up for photozincography.
Do. Lohardugga and Chota Nagpore	4	1 = 4	Corrected to date.
Do. Kohat	1	1 = 4	Compiled from latest materials.
Do. Hooghly	1	1 = 4	Ditto ditto.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS AND PROGRESS.
		In. Mls.	
Administration Report Maps.			
North-West Provinces	1	1 = 80	Corrections and additions for Government North-West Provinces.
Punjab	1	1 = 32	Corrections and additions for Punjab Government and Superintendent of Forest Surveys.
Do.	1	1 = 80	
Central Provinces	1	1 = 32	
Ditto	1	1 = 80	
Central India	1	1 = 80	
Bengal	1	1 = 80	
Assam	1	1 = 80	
PROVINCE OF BENGAL—			
Districts Nuddea, Khoolna, Midnapore, Dacca, Noakholly, 24-Pergunnahs, Beerbhoom, Korea, Monghyr, Gya, Tipperah, Chang-Bhakar, Singhbhum, Bonai, Sundarbans, Orissa, Tributary Mehals.	16	1 = 8	Reduced from Atlas sheets, &c.
CENTRAL PROVINCES—			
Districts Bhandara, Mandla, Seoni, Hoshangabad, Betul, Raipur, Balaghat, Bilaspur, Sironcha, Nimar, Narsinghpur, Damoh, Chanda, Nagpur, Sambalpur and Wardha.	16	1= 8	Ditto ditto.
NORTH-WEST PROVINCES AND OUDH—			
Districts Sultanpur, Gonda, Moradabad, Agra, Basti, Banda, Etawah, Etah, Lucknow, Mirzapur, Bahraich, Gorakhpur, Shahjahanpur and Muzaffarnagar.	14	1= 8	Ditto ditto.
PROVINCE OF ASSAM—			
Districts Sibsagar, Kamrup, Sylhet, Nowgong, Goalpara and Naga Hills.	6	1= 8	Ditto ditto.
PROVINCE OF PUNJAB—			
District Muzaffargarh	1	1= 8	Ditto ditto.
Index Maps.			
Provincial Index, Sind	1	1=32	Drawn for reduction by photozincography.
Ditto Bombay	1	1=32	
Ditto Madras I	1	1=32	
Ditto Ditto II	1	1=32	
Ditto Nizam's Dominions.	1	1=16	
North-West Trans-frontier	1	1=64	Re-drawn for ditto ditto.
Cutch Topographical Survey	1	1=18	Table of new and old Index numbers added.
Gujarat Survey	1	1=24	Ditto ditto.
Miscellaneous Maps.			
Map of Sundarbans	2	1= 4	Additions for photozincography.
Charts of Arabian Sea, Indian Ocean, and Gulfs of Aden and Persia.	9	1=37	For the Meteorological Reporter for Western India for reduction by photozincography to ·1″=145 miles.
Military Map of India	6	1=32	On Skeleton India, 1″=32 miles, Military Outposts and Cantonments, also Railways open and under construction added, for reproduction by photozincography.
Map showing boundaries claimed by Maharajah Holkar.	1	1= 4	Prepared for Secretary of State for India, by combining Atlas Sheets, Nos. 37 N.E., S.E. and 54.
Map of Rewah	1	1=32	Prepared by transfer from copper plate for Political Agent; Rajputana.
Table showing Trade of India with the World.	1	....	For Revenue and Agricultural Department, for reproduction by photozincography.

DRAWING OFFICE, CALCUTTA.

SECTION II. REVENUE.

Statement showing the work performed and the progress made from 1st October 1885 to 30th September 1886.

TITLE OF MAPS.	Number and size of sheets.	Scale.	REMARKS.
		In. Mls.	
PUNJAB.			
District Hissar	14 (30′ × 15′)	1 = 1	Nos. 242, 243, 257, 258, 259, and 260, completed up to margin and examined. Nos. 241, 256, and 261, in progress. No. 244, reduced by pentagraph and completed up to margin, from details obtained from the 1" sheets of District Sirsa and Bickaneer State.
Do. do.	29 sections. (15′ × 7′ 30″)	2 = 1	Nos. 242 S. E., 243 N. E. S. E., 257, 258, 259, 260, and 261, passed with final press order.
District Rawalpindi (Kahuta Forest).	13 sections. (7′ 30″ × 3′ 45″)	4 = 1	Nos. 160 $\left(\frac{\text{N.E.}}{1,2,3,4}\ \frac{\text{S.E.}}{2,4}\right)$, 161 $\left(\frac{\text{N.E.}}{2,3}\ \frac{\text{S.E.}}{2}\right)$, 183 $\left(\frac{\text{S.W.}}{3}\right)$, 186 $\left(\frac{\text{S.W.}}{1,2,3,4}\right)$, examined and sent to press. Proofs examined of Nos. 160 $\left(\frac{\text{S. E.}}{1,3}\right)$, 161 $\left(\frac{\text{S.E.}}{3 \text{ and } 4}\ \frac{\text{N.E.}}{1}\right)$, 162 $\left(\frac{\text{N.E.}}{1,2,3,4}\right)$, 185 $\left(\frac{\text{S.W.}}{2,3,4}\right)$, and 186. $\left(\frac{\text{N.W.}}{1,2,3,4}\right)$ Publication deferred pending settlement of Forest Boundaries.
District Karnal (Government Cattle Farm).	4	16 = 1	Nos. 1, 2, 3, 4 examined and sent to press.
District Delhi	6	1 = 1	Nos. 298, 299, 319, 320, 321, and 322 corrected, and sent to press for second edition.
NORTH-WESTERN PROVINCES.			
Meerut Division.			
Districts Aligarh and Etah .	15 sections. (7′ 30″ × 15′)	2 = 1	No. 35 final press order given. Nos. 23, 36, 37, 52 and 53 examined and sent to press.
Ditto ditto .	6 (30′ × 15′)	1 = 1	No. 23 under examination. Nos. 36, 37, 52, and 53 examined and being completed up to margin.
District Gorakhpur . .	8 sections. (30′ × 15′)	1 = 1	Skeleton sheets, showing trijunctions of villages, Nos 207 N.E. S.E., 208 N.E. S.E., 216 N.W. S.W., and 217 N.W. and S.W., were received. No. 207 N.E. S.E., details reduced by pentagraph from the 16-inch cadastral plans, drawn and typed. No. 208 N.E. S.E. in hand.
District Mirzapur . . .	12 in 31 sections. (30′ × 15′)	1 = 1	Nos. 168 S.E.; 169 N.E., S.E.; 170 N.W., N.E., S.W., S.E.; 171 N.E., S.E.; 181 S.W., S.E.; 182 N.E., N.W., S.W., S.E.; 183 N.E., N.W., S.E., S.W.; 184 N.W., N.E.; 197 N.W., S.W., 198 N.W., S.E., S.W., 199 N.E., N.W., S.E., S.W. and 212 N.W. converted into blue prints: 29 sections drawn and typed; remainder in hand.
Benares Division.			
Districts Ghazipur, Ballia, &c. .	13 in 37 sections. (30′ × 15′)	1 = 1	Nos. 194, 195, 196, 197, 208, 209, 210, 211 217, 218, 219, 220, and 221 received. Nos. 208, 210, 211, 217, 218, 219, preliminarily examined and under correction. No. 209 examined and sent to press.
Benares City (including Sikrol and Pandipur Cantonments).	4 (2′ 45″ × 3′ 30″)	8 = 1	Projected. Plotting of points in hand.
Ganges and Gogra Rivers .	40 sections. (7′ 30″ × 3′ 45″)	4 = 1	Nos. 210 $\left(\frac{\text{E.}}{2,4}\right)$, 211 $\left(\frac{\text{N.E.}}{2}\right)$, 217 $\left(\frac{\text{S.W.}}{1,2,3,4}\ \frac{\text{S.E.}}{3}\right)$, 218 $\left(\frac{\text{N.W.}}{2}, \frac{\text{N.E.}}{1,2,3,4}, \frac{\text{S.E.}}{2}\right)$, 219 $\left(\frac{\text{N.W.}}{1,2,3,4}, \frac{\text{N.E.}}{1,2,3,4}, \frac{\text{S.W.}}{1,2,3,4}, \frac{\text{S.E.}}{1,2}\right)$, 220 $\left(\frac{\text{N.W.}}{3}, \frac{\text{S.W.}}{1,2,3,4}, \frac{\text{S.E.}}{3}\right)$, 221 $\left(\frac{\text{N.W.}}{1,2,3,4}\ \frac{\text{N.E.}}{1,2,3}\right)$, received. No. 219, 13 sections preliminarily examined.
Oudh	6 (30′ × 15′	1 = 1	Nos. 136, 150, 163, 164, 174, 176, and 177, press order given. Nos 104, 116, 122, 132, 137, sent to press for corrections and omissions to be supplied.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

TITLE OF MAPS.	Number and size of sheets.	Scale.	REMARKS.
		In. Mls.	
CENTRAL PROVINCES.			
Saugor City	4 sections.	8 = 1	Final press order given.
BENGAL.			
District Cuttack	3 (30′ × 15′)	1 = 1	Nos. 225, 226, 227 remain in hand.
District Midnapur . . .	1	1 = 4	Final press order given.
Hooghly River Survey . .	9 in 116 sec.	16 = 1	Proofs examined and final press order given.
Ditto ditto . .	1·4 in 8 sec.	6 = 1	Originals and proofs examined. Final press order given.
Ditto ditto . .	5·9	6 = 1	Examined for press.
Ditto ditto . .	1·10	3 = 1	Final press order given,
Ditto ditto . .	1 & 2	1 = 1	Originals and proofs examined. Final press order given.
Jalpaiguri	12 (30′ × 15′)	1 = 1	Nos. 270, 271, 272, 295, 296, 316, 317, 318, and 337. Final press order given. Nos. 293, 294, and 315 sent to press for correction.
BOMBAY.			
Konkan Survey . . .	4 (30′ × 15″)	1 = 1	Nos. 161, 135, 167, and 141 examined. Proofs Nos. 136 and 162 examined and final press order given. Nos. 161 and 135 sent to press for publication.
Do. do. . . .	53 (7′ 30″ × 3′ 45″)	4 = 1	Nos. 159 (1 section), 160 (10 sections), 133 (4 sections), 134 (8 sections) examined and sent to press. Proofs Nos. 162 (8 sections), 161 (16 sections), 136 (8 sections), examined. Press order given for preliminary edition.
Deccan Survey . . .	5 (30′ × 15′)	1 = 1	Proofs of Nos. 238 and 270 examined and sent to press for correction. Nos. 169, 170, 171, 203 and 239, examined. Nos 169, 170, 171, sent to press for reduction to half scale.
BURMA.			
Districts Hanthawaddy, Pegu and Shwegyin.	4-(14 sections.) (7′ 30″ × 15″)	2 = 1	Proofs Nos. 96, 112, 97, 127, 98, 114, and 128 passed with press order for preliminary edition. Nos. 123, 124, 125, and 126 examined and sent to press for preliminary edition.
Districts Bassein and Henzada .	11 (30′ × 15′)	1 = 1	Nos. 65, 79, 80, 96, 66, 81, 82, 67, 77, 78, and 97 examined with 16″ inch plans and under correction.
District Tharrawaddy . .	5-in 19sections. (15′ × 7′ 30″)	2 = 1	Proofs of Nos. 93, 94 and 95 passed with press order for preliminary edition.
District Prome . . .	6 (30′ × 15′)	1 = 1	Proof of No. 92 sent to press. No. 93 sent to press. Nos. 74, 75, 76, and 77 drawn and under examination.
Provincial Index Map of Bengal	1	1 = 52	Drawn on scale of 1″ = 32 miles for reduction to 1″ = 52 miles.
Annual Report Index Maps, Index to the Survey Operations in the Punjab, Bilaspur, Raipur, Jubbulpore, Sambulpur, (Central Provinces), Basti, Gorakpur (North-West Provinces), Kamrup, Darrang, (Assam), Mozufferpore (Bengal), Ajmére (Rajputana), Akyab (Burma), Deccan and Konkan, and South Maratha (Bombay).			Index Maps to the Survey Operations in Bilaspur, Raipur, Jubbulpur, Mozufferpore, and South Maratha were redrawn; others revised and brought up to date for Annual Report of 1885-86.
Examination of proofs.			
Photozincographed maps . .	537		
Lithographed maps . . .	42		

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

DESCRIPTION OF WORK.	REMARKS.
Computations examined.	
District Hissar, Seasons 1882—84.	
„ Dehra Dun, Seasons 1883—85.	
„ Shewgyin, Seasons 1883—85.	
Traverse data, &c., supplied.	
Traverses of 10 villages of District Bhagalpore .	For Collector of Bhagulpore.
„ of 24 „ „ Mozufferpore .	For Civil Superintendent of Survey.
„ of District Jaunpur along District Mirzapur.	For W. H. Patterson, Esq., Deputy Superintendent.
„ of Main Circuit No. 10, Mirzapur, along portion under Topographical Survey.	Ditto ditto.
„ of Pargana Chainpur, District Shahabad, along District Mirzapur.	Ditto ditto.
„ of 12 villages of District Nuddea . .	For Settlement Deputy Collector.
„ of 38 „ „ Moorshedabad .	For Collector of Moorshedabad.
„ of 1 Frontier Circuit, District Sylhet .	For Secretary, Chief Commissioner, Assam.
„ of Main Circuit Nos. 2, 3, 4, District Larkhana, along Kalat.	For Mr. McNair, Surveyor.
„ of Main Circuit No. 2 Kohishtan . .	Ditto ditto.
„ of 4 villages (old and new Surveys), District Moorshedabad.	For Collector of Moorshedabad.
„ of 12 villages of District Patna . .	For Collector of Patna.
„ of District Benares, along the unsurveyed portion of District Mirzapur	For Deputy Superintendent.
„ of Mirzapur villages, (12 pages) . .	For Major Sandeman.
„ of Cachar Tea Grants, (6 pages) . .	For Deputy Commissioner.
„ of District Bassein, along District Thonkwa(19 pages).	For Deputy Superintendent.
Field Area Statements of District Pegu (139 pages)	For Superintendent of Survey and Settlement.
Values and Description of Level Bench marks in District Agra (40 pages).	For Executive Engineer, Irrigation Department.
Triangulation data of Kohistan, Circuit No. 2.	For Mr. McNair, Surveyor.
Miscellaneous.	
Preparation of a statement showing Area, Total Cost, and Rate per Square Mile of the Districts in the North-West Provinces.	For Revenue Board, North-West Provinces.
Computation of Lat. and Long. for the projection of Hutted Camps, District Hazara, as well as for the projection of District Burdwan; also rectangular co-ordinates for the projection of certain sheets of the Hooghly River Survey and of the City and Cantonment of Benares.	
Preparation of Area Statements of Districts Jaunpur by Parganas, of District Raipur by Zemindaries, and of District Henzada by Townships.	
Computation of Lat. and Long. of Nimar Triangulated points.	
Preparation of a list of all the villages in District Chittagong, showing their state of demarcation.	For Revenue, Agriculture and Commerce Department.
Preparation of a statement showing Areas of Districts in the Punjab according to revised boundaries.	For Director of Settlements.
Plotting of Jungle Circuit No. 1, District 24-Parganas.	For Collector.
Calculation of Areas of Districts Jhelum, Simla, Umballa, Kohat, Rawalpindi and Akyab, also of Kulu State in District Kangra, and of the Districts in the Hyderabad State.	
Preparation of a General Statement for all India showing the population in every District or State according to religion for the preparation of a Religion Map of India.	

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

TITLE OF MAPS.	Scale.	REMARKS.
Tracings.		
Copies of 8 village plans of Pargana Nathpur, District Pubna (transferred to District Bhagalpur).	4=1	For Collector.
Tracings of 2 village plans of Pargana Nathpur, District Pubna (transferred to District Bhagalpur).	4=1	Ditto.
Copy of 1 village plan of Pargana Muhumud Shahee, District Pubna.	4=1	For Deputy Collector, Kooshtea.
Copies of 3 village plans of Pargana Sahaujal, District Nuddea.	4=1	Ditto ditto.
Copies of 3 village plans of Pargana Taragunia, District Nuddea.	4=1	For Collector of Pubna.
Tracings of 3 villages, Ganges Deara Survey.	4=1	Ditto ditto.
Copies of 2 village plans of Pargana Taragunia, and Sahaujal, District Nuddea.	4=1	For Deputy Collector, Nuddea.
Copy of 1 village plan of Pargana Medanmal, District 24-Parganas.	4=1	For Collector.
Copies of 2 village plans of Parganas Calcutta and Buran, District 24-Parganas.	4=1	Ditto.
Tracing of portion of boundary between District Sylhet and Hill Tipperah.	4=1	For Chief Commissioner, Assam.
Ditto ditto.	1=1	Ditto ditto.
Tracings of 6 village plans of Pargana Salempur Majhauli, District Gorakhpur.	4=1	For Major Sandeman, Deputy Superintendent.
Tracings of 12 village plans of Pargana Kalyanpur Kuwari, District Saran.	4=1	Ditto ditto.
Tracings of 3 village plans of Pargana Chaubara, District Saran.	4=1	Ditto ditto.
Copies of 2 village plans of Pargana Goa, District Saran.	4=1	For Collector, Saran.
Tracing of portion of boundary between Kalat and District Larkhana.	4=1	For Mr. McNair.
Ditto ditto.	2=1	For Ditto.
Ditto ditto.	1=1	For Ditto.
Copies of 3 village plans of Pargana Jamuni, District Bhagalpur.	4=1	For Deputy Collector, Maldah.
Tracing of Pargana Kankjaul, District Purnea, Season 1847.	4=1	Ditto ditto.
Tracings of 4 villages of the Ganges Deara Survey.	4=1	Ditto ditto.
Tracings of 3 village plans of Parganas Laskarpur and Goas, District Nuddea.	4=1	Ditto ditto, Nuddea.
Tracing of 1 village plan of Pargana Goas, District Moorshedabad	4=1	Ditto ditto.
Tracing of portions of Sheets Nos. 13, 14, 17, 18, and 20, Main Circuit No. 10, Ganges Deara Survey (in duplicate).	4=1	For Sub-Divisional Officer, Barh.
Tracing of portion of Sheet No. 10, Main Circuit No. 8 Ganges Deara Survey (in duplicate).	4=1	Ditto ditto.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

TITLE OF MAPS.	Scale.	REMARKS.
Tracing of Jungle Circuit and adjoining villages, Pargana Medanmal District, 24-Parganas.	4=1	For Collector.
Copy of 1 village plan of Pargana Sahaujal, District Nuddea.	4=1	For Settlement Officer.
Tracings of Sheets Nos. 26, 33 and 35, Bijeraghogarh District, Jubbulpore.	4=1	For G. H. Cooke, Esq., Deputy Superintendent.
Tracings of 3 village plans of Pargana Baraich, District Baraich.	4=1	For Executive Engineer, Kapurthala State.
3 Tracings of Reserved Forest Tracts in Tahsil Bijeraghogarh, District Jubbulpore.	4=1	For G. H. Cooke, Esq., Deputy Superintendent.
2 Tracings of Reserved Forest Tracts in Parganas Sonpur and Singorgarh, District Jubbulpore.	4=1	Ditto ditto.
Copies of 2 village plans of Pargana Kentunagar, District Moorshedabad.	4=1	For Collector.
Copy of 1 village plan of Pargana Hajeepore, District Mozufferpore	2=1	For Sub-Divisional Officer, Barh.
Tracing of Sheet No. 5, Main Circuit No. 8, Ganges Deara Survey.	4=1	Ditto ditto.
Copy of 1 village plan of Pargana Futehsingh, District Moorshedabad.	4=1	For Collector.
Tracing of Grant No. 18 (old rules) District Lakhimpur.	4=1	For Settlement Officer.
Copies of 2 village plans of Pargana Kasimnagar, District Maldah.	4=1	For Collector.
Copy of 1 village plan of Pargana Esuphshahi, District Pubna.	4=1	Ditto
Copies of 7 village plans of Pargana Poladassi, District Bogra.	4=1	Ditto
Tracing of portion of boundary between Districts Mirzapur and Benares.	2=1	For W. H. Patterson, Esq., Deputy Superintendent.
Tracing of portion of Boundary between Districts Mirzapur and Shahabad.	1=1	Ditto ditto.
Copies of 290 village plans of Pargana Bisara Tappa Bhatsalla Districts Mozufferpore.	4=1	For Settlement Officer.
Tracing of portions of Sheets Nos. 13, 14, 17, 18, 20, Ganges Deara Survey.	4=1	For Deputy Collector, Nuddea.
Copies of 122 village plans of Pargana Gadeshar, District Mozufferpore.	4=1	For Settlement Officer.
Copies of 754 village plans of Pargana Bisara (Chakla, Girjaul), District Mozufferpore.	4=1	Ditto ditto.
Copies of 339 village plans of Pargana Ratti, District Mozufferpore.	4=1	Ditto ditto.
Copies of 225 village plans of Pargana Hajeepore, District Mozufferpore.	4=1	Ditto ditto.
Map colouring.	Number.	
Maps on various scales.	207	For Surveyor General's Office.
Ditto ditto . . .	207	For Deputy Surveyor General's Office.
Ditto ditto . . .	892	For India Office.
Ditto ditto . . .	512	For District officials.

DRAWING OFFICE, CALCUTTA.

EXAMINING SECTION.

Work done from the 1st October 1885 to 30th September 1886.

TITLE OF MAP.	Number of Sheets.	Scale. In. Mls.	REMARKS AND PROGRESS.
Original Standard Sheets	26	4= 1	Examined with plane-table sheets and carried out corrections for photozincography.
	12	2= 1	
	12	1= 1	
	7	1= 2	
	9	1= 4	
	1	1= 8	
Original Large Scale Plans	9	24= 1	Simla sheets. Examined revised contours for photozincography.
	22	12= 1	Examined with plane-table sheets for photozincography.
	4	10= 1	
	2	6= 1	
Original Triangulation Charts	1	2= 1	Examined for photozincography.
	1	1= 2	
	1	1= 4	
Original Atlas Sheets for reduction by Heliogravure.	2	1= 3	Examined and given to Draftsmen.
Original Atlas Sheets, or portions thereof, compiled in Drawing Office and received from field parties.	35	1= 4	Examined and sent to Engraving Office.
General and Provincial Maps	1	1= 10	Examined additions to railways, hills, &c., mostly for the Engraving Office.
	11	1= 16	
	19	1= 32	
	4	1= 64	
District Maps compiled in Drawing Office	9	1= 4	Examined for photozincography.
Index Maps prepared in ditto	1	1= 12	
	2	1= 16	
	3	1= 24	
	7	1= 32	
	2	1= 64	
	1	1=128	
Special Maps compiled in Drawing Office for various purposes	1	1= 2	
	4	1= 4	
	24	1= 8	
	30	1= 16	
	3	1= 32	
Engraved proofs of Atlas Sheets in various stages.	114	1= 4	Examined and sent to Engraving Office.
Engraved proofs of General and Provincial Maps	2	1= 8	Examined mostly additions and corrections made on copper-plates from time to time.
	9	1= 16	
	7	1= 32	
	16	1= 64	
	8	1= 80	
	3	1=128	
Lithographic proofs of Atlas Sheets and District Maps transferred from copper-plates.	8	1= 4	Examined corrections in territorial changes and public constructions, such as boundaries, canals, roads, &c.
Lithographic proofs of General and Provincial Maps, including Index Charts.	6	1= 16	Examined additions and corrections made on stones from time to time.
	14	1= 32	
	4	1=128	
	2	1=256	
Lithographic proofs of Special and Miscellaneous Maps.	1	1= 16	Examined and given to Draftsmen.
	13	1= 32	
	6	1= 80	
	1	1=128	

DRAWING OFFICE, CALCUTTA.

EXAMINING SECTION—*continued.*

TITLE OF MAP.	Number of Sheets.	Scale. In. Mls.	REMARKS AND PROGRESS.
Photographic proofs of Standard Sheets, large scale Plans and various other Maps	27	24 = 1	Examined and given to Draftsmen.
	41	12 = 1	
	4	6 = 1	
	77	4 = 1	
	31	2 = 1	
	90	1 = 1	
	22	1 = 2	
	33	1 = 4	
	97	1 = 8	
	1	1 = 10	
	2	1 = 12	
	6	1 = 16	
	1	1 = 18	
	3	1 = 24	
	35	1 = 32	
	5	1 = 48	
	7	1 = 64	
	2	1 = 70	
	2	1 = 128	
	1	1 = 256	
	16	1 = 200 ft.	
Projection and Examination of graticules and plotting of points.	45		
TOTAL	1,007		

N. B.—In addition to the above, miscellaneous jobs, such as tracings of sketches, charts, supply of geographical data to various officials, calculation of areas, computation of graticules for the plates of the Indian Atlas and testing the same on copper, have been performed by the Examining Section, as well as various other minor works too numerous to be mentioned here.

DRAWING OFFICE, CALCUTTA.

State of Publication of Cadastral Maps on the 30th September 1886.

Districts.	Number of Sheets. Maps Prepared. Up to 30th September 1885.	Added during past 12 months.	Total up to 30th September 1886.	Published. Up to 30th September 1885.	By Surveyor-General's Office during past 12 months.	Total to 30th September 1886.	Remaining to be published.	Remarks.
North-West Provinces.								
Agra	2,924	...	2,924	2,924	...	2,924	...	
Aramgarh	930	...	930	930	...	930	...	
Ballia	1,384	10	1,394	1,384	10	1,394	...	
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	1,402	1,608	3,010(b)	...	199	199	2,811	
Benares	1,444	371	1,815	1,014	796	1,810	5	
Bijnour	31	...	31	31	...	31	...	
Dehra Dun	704(a)	...	704(b)	188	463	651	50	(a) Figures of previous return have been changed to agree with final results.
Ghazipur	3,050	...	3,050	3,050	...	3,050	...	
Gorakhpur	1,795	1,448	3,243(b)	...	1,123	1,123	2,120	
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,434	...	3,434	3,434	...	3,434	...	
Moradabad and Terai	4,023	...	4,023	4,023	...	4,023	...	
Muttra	1,658	...	1,658	1,658	...	1,658	...	(b) These figures are liable to alteration until publication has been completed.
Mirzapur	3,658	...	3,658	3,638	...	3,638	20	
Tarai	316	...	316	316	...	316	...	
Total	33,023	3,437	36,460	28,863	2,591	31,454	5,006	
Lower Burma.								
Akyab	915(c)	915	1,861(b)	107	510	617	1,214	(c) Includes 39 sheets of Akyab town surveyed on the scale of 64 inches to the mile.
Bassein	3,076(a)	...	3,076	2,813	263	3,076	...	
Hanthawaddy and Pegu	4,001	...	4,001	4,008	...	4,001	...	
Henzada	1,391(a)	...	1,391	543	848(d)	1,391	...	
Prome	817	...	817	797	50(e)	817	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	...	(d) Includes 3 sheets of Henzada City surveyed on the scale of 64 inches to the mile.
Total	12,224	915	13,139	10,224	1,701	11,925	1,214	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	(e) Includes 10 sheets of Prome Town on the scale of 64 inches to the mile.
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Pooree (Khorda State)	4,565(a)	...	4,565	4,490	75	4,565	...	
Total	12,543	...	12,543	12,468	75	12,543	...	
Assam.								
Kamrup	1,021(a)	653	1,677(b)	383	640	1,023	654	
Sylhet	61	...	61	16	...	16	45	
Total	1,085	653	1,738	399	640	1,039	699	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
Total	43	...	43	43	...	43	...	
Grand Total N.-W. Provinces, Burma, Bengal, Assam, and Central Provinces	58,918	5,005	63,923	51,997	5,007	57,004	6,929	

Abstract of work performed during past year.

Provinces.	Number of Sheets. Examined and rendered suitable for photo-zincography.	Traced and examined for zincography.	Proof copies examined previous to press order.	Coloured and subsequently examined.	Remarks.
North-West Provinces	1,542	1,038	2,751	2,591	¾ Scale 16 inches = 1 mile.
Lower Burma	1,180	561	1,818	1,701	
Bengal	...	...	44	75	" 22 ditto.
Assam	404	234	641	640	" 16 ditto.
Total	3,126	1,833	5,254	5,007	

ENGRAVING OFFICE, CALCUTTA.

Report of progress from 1st October 1885 to 30th September 1886.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks showing Progress.
	Sq. In.	Letters Cut.	Sq. In.	
General Maps, &c.				
India, in six sheets, scale 1 inch =32 miles. Sheet 1	28	820	32 H.	Additions; hills in progress.
„ 2	8	669	...	Small portion of outline and writing finished.
„ 3	12	425	...	Additions; hills in progress.
„ 4	...	...	...	Corrections and additions in progress.
„ 5	...	740	...	Ditto completed.
„ 6	...	...	...	Slight corrections, completed.
India, in four sheets, scale 1 inch =64 miles.	13	1,063	24 H.	Plates brought up to date, additional railways, &c.
Skeleton Map of India, in four sheets, scale 1 inch=64 miles.	...	567	...	Corrections, finished.
India, in two sheets, scale 1 inch =80 miles.	...	423	...	Ditto.
India, scale 1, inch=128 miles	...	146	23 H.	Ditto.
Bengal, in two sheets, scale 1 inch=16 miles.	...	...	100 H.	Hills well advanced on sheet 1.
Rajputana, in two sheets, scale 1 inch=16 miles.	21	1,672	28 H.	Hills in progress.
Central India Agency, in two sheets, scale 1 inch=16 miles	...	2,120	...	Additional writing.
Central Provinces, in two sheets, scale 1 inch=16 miles.	...	36	...	Slight additions, completed.
North-West Provinces and Oudh, in two sheets, scale 1 inch=16 miles.	...	816	...	Projected, border cut, outside, figures in progress.
Punjab, in four sheets, scale 1 inch=16 miles.	556	...	...	Outline well advanced; in progress.
Assam, scale 1 inch=16 miles	...	35	...	Slight additions.
Berar, scale 1 inch=8 miles	...	522	23 H.	Plate completed and published.
Index Chart to the Great Trigonometrical Survey.	...	40	...	Additions and corrections, completed.
Patna Division, scale 1 inch =16 miles.	...	1,396	...	Ditto to outline, and writing.
Bay of Bengal Weather Chart.	36	4,342	...	Projected, border cut, outline writing and tint on land, engraved; completed.
Native Officers' Commission Form.	...	12,050	...	New plate engraved, one half in the Persian character, the other in ornamental lettering.
The Viceroy's Appointment plate, Lord Dufferin's Crest.	...	1,000	...	Completed.
Three Tints, Nos. 16, 17, 18, measuring 20 inch × 14 inch.	...	200	...	Ditto.
Three Tints, measuring 18 inch ×12 inch.	...	483	...	Engraved, for Photozinco. Office, Poona.
Two scales, 16 inch=1 mile . 1 chain=48·75 feet or ¼ side of a Bigah.	...	640	...	Completed.
Scale 80 Kadams=1 inch	...	386	...	Completed.
Scale 2·995 inch=100 Lagis in Nagri character.	...	662	...	
Bigah Comb scale, 16 inches =1 mile.	...	379	...	
Scale 3⅓ chains=1 inch or 24 inch = 1 mile.	...	530	...	
Scale 16 inches=1 mile	...	564	...	
Scale of chains 2 inches=1 mile.	...	190	...	
Indian Atlas border	...	763	...	Blank plate of border, scale, and outside figures only engraved.
Imprint plates	...	200	...	Three plates corrected.
Vernier scales	...	3,242	...	Forty-six scales figured for Mathematical Instrument Office.
Theodolite circles	...	3,014	...	Seven figured ditto.
Brass Sun Dial	...	848	...	Figured ditto.
Zenith Sector in heliogravure	...	750	...	Title engraved.
Two plates of the Archæological Survey of Western India, in heliogravure.	...	782	...	Titles and lettering engraved.
Photo-electrotype plate	...	278	...	Title engraved.
Heliogravure plates by Colonel J. Waterhouse.	...	6,184	...	Titles and lettering engraved on fifteen plates.
Total	674	48,977	230 H.	

ENGRAVING OFFICE, CALCUTTA.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks showing Progress.
	Sq. In.	Letters cut.	Sq. In.	
Indian Atlas Sheets (New) completed.				
12 S. W.	...	300	4 H. 14 jungle.	Completed.
38 S. E.	...	272	36 H.	
38 S. W.	3	771	97 H.	
39 S. W.	...	688	171 H.	
40 N. E.	5	1,636	200 H.	Completed up to margin.
49 N. E.	...	1,926	...	
49 S. E.	...	819	8 H. 20 jungle	
67 N. W.	...	1,949	...	
67 S. W.	...	17,625	...	
Total	8	25,986	516 H. 34 J.	
Indian Atlas Sheets (New) in progress.				
6 N. E.	...	711	...	Additional writing completed.
11 S. W.	80	...	...	Projected, border cut; outline in progress.
12 N. E.	53	3,257	...	Additional outline, writing, and outside figures engraved.
12 N. W.	172	3,283	...	Reprojected, new border, scale, and outside figures cut, outline completed, writing in progress.
14 N. E.	...	4,335	...	Writing finished as far as material supplied.
14 S. E.	...	7,175	...	Writing in progress.
15 N. W.	...	8,511	...	Scale and outside figures cut; writing in progress.
15 S. W.	...	13,375	16H.	Outline and writing finished; hills in progress.
16 N. W.	223	...	...	Outside figures cut, outline finished as far as material supplied.
16 S. W.	212	152	15S H.	Outline finished as far as material supplied, sandy bed of river dotted; outside figures in progress.
18 S. E.	...	...	53S. H.	Sand hills well advanced; in progress.
19 S. E.	...	...	65S. H.	Ditto ditto.
20 S. E.	16	842	15H.	Outline and writing finished, waiting hill drawing.
21 S. E.	...	6,448	...	Outside figures cut, outline and writing finished as far as material supplied.
21 S. W.	20	1,828	...	Reprojected, new border cut, outline and writing finished as far as material supplied.
22 N. E.	89	5,883	...	Outline finished as far as material supplied, writing in progress.
23 N. E.	7	600	...	Outline and writing finished as far as material supplied.
23 S. E.	...	7,321	...	Ditto ditto.
35 S. W.	40	1,167	20H.	Hills in progress.
36 N. W.	18	4,341	...	Outline and writing finished as far as material supplied.
36 S. W.	14	640	...	
37 N. W.	114	1,224	...	Border, scale, and sand banks cut; writing in progress.
37 S. W.	39	446	...	Portion of additional outline engraved; writing in progress.
38 N. E.	...	8,334	..	Outline and writing nearly finished as far as material supplied.
38 N. W.	4	20	...	Additional railways and writing engraved.
39 N. E.	...	392	...	Outside figures in progress, writing about to be commenced.
39 N. W.	5	4,376	33 H.	Writing completed; hills in progress.
39 S. E.	...	13,607	8 H.	Writing completed; hills just commenced.
40 N. W.	80	2,490	...	Outline completed as far as material supplied; writing in progress.
Carried over	1,186	99,738	92 H. 133 S. H.	

N.B.—A full sheet of the Indian Atlas contains 927²⁄₃ square inches.

ENGRAVING OFFICE, CALCUTTA.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. In.	Letters cut.	Sq. In.	
Indian Atlas Sheets (New) in progress—continued.				
Brought forward	1,186	99,738	92 H. 133 S. H.	
40 S. E.	15	1,214	...	Outline and writing completed as far as material supplied.
42 S. E.	...	3,600	...	Writing in progress.
43 N. E.	...	2,914	...	
43 S. E.	13	1,543	...	Scale cut; outline and writing finished as far as material supplied.
48 N E.	...	1,727	...	Writing in progress.
48 S. W.	...	5,975	...	Outline and writing finished as far as material supplied.
49 N. W.	85	6,120	...	Scale cut; outline and writing finished as far as material supplied.
49 S. W.	...	2,512	...	Outline and writing finished as as far as material supplied.
50 N. E.	207	10,972	...	Outline completed to margin; writing in progress.
50 N. W.	10	1,869	...	Outline and writing finished as far as material supplied.
60 N. E.	16	10,000	...	Writing in progress.
60 N. W.	3	18,314	...	
60 S. E.	...	9,722	...	
61 N. E.	19	...	...	Outline completed up to margin; writing in progress.
61 S. E.	...	702	...	Rivers waterlined; additional writing cut; waiting hill drawing.
68 N. W.	75	...	...	Outline completed as far as material supplied; writing about to be gone on with.
76 N. E.	...	200	...	Slight additons; finished; waiting hill drawing.
76 S. W.	...	370	...	Rivers waterlined; lakes shaded; additional writing cut; waiting hill drawing.
77 S. E.	...	606	...	District names engraved; waiting hill drawing.
78 N. E.	25	4,086	...	Rivers waterlined; additional writing cut.
79 N. W.	...	3,717	...	Additional writing cut.
79 S. W.	5	...	...	Rivers waterlined.
88 N. E.	135	2,107	...	Scale cut; outline completed as far as material supplied; writing in progress.
88 S. E.	3	...	...	Outline completed as far as material supplied.
88 S. W.	...	777	16 H.	Completed as far as material supplied.
103 N. W.	50	96	...	Outline completed as far as material supplied.
103 S W.	41	96	...	
114 N. E.	...	8,813	...	Outline and writing completed as far as material supplied.
114 S. E.	...	1,299	...	
114 S. W.	131	14,604	...	Writing well advanced; in progress.
115 N. E.	...	100	...	Slight additions completed.
125 S. E.	4	3,449	...	Scale and outside figures cut; writing in progress.
Total	2,023	218,262	108 H. 133 S.H.	
Additions and Corrections to the Indian Atlas Sheets.				
2 S.E.	...	...	...	Slight corrections completed.
8 S.E.	...	...	...	
8 S.W.	8	885	8 Jungle	Additional railway, outline, and writing, completed.
13 S E.	...	50	...	Slight corrections completed.
19 N E.	...	10	...	
Carried over	8	945	8 Jungle	

ENGRAVING OFFICE, CALCUTTA.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks showing Progress.
	Sq. In.	Letters cut.	Sq. In.	
Additions and Corrections to the Indian Atlas Sheets—contd.				
Brought forward .	8	945	8 Jungle	
28 S.E.	...	2,600	...	Corrections made on the matrices, electrotyped from the old full plate 28.
28 S.W.	...	2,750	...	
31 N.W.	6	740	...	Heavy corrections and additions finished.
31 S.E.	...	1,907	...	Outline and writing of heavy corrections and additions finished; waiting hill drawing.
31 S.W.	...	169	...	Corrections and additions finished.
32 N.E.	...	4,776	5 S.H. 15 Jungle	District names, boundaries and corrections, finished.
32 N.W.	...	...	...	Slight corrections completed.
32 S.E.	...	12	...	
34 N.E.	...	...	...	
34 S.E.	...	...	...	
36 N.E.	...	241	...	Slight additions completed.
37 S.E.	...	...	...	Slight corrections to outline finished.
48 S.E.	...	204	...	Slight additions completed.
53 N.E.	...	73	...	
66 N.E.	...	68	...	
66 S.E.	...	390	...	
66 S.W.	...	414	...	Additional railway, boundaries and names cut.
67 N.E.	...	62	...	Additional canals and names completed.
67 S.E.	...	404	...	Additional Railways, canals and names completed.
69 S.E.	...	44	...	Slight additions completed.
77 N.E.	...	60	...	District names finished.
87 N.E.	...	230	...	Additions completed.
87 S.E.	8	1,597	...	Railways, corrections to outline and names, completed.
91 N.W.	...	23	...	Slight corrections to outline and writing, completed.
91 S.E.	...	47	...	
Total .	22	17,786	5 S.H. 23 Jungle	
Corrections and Additions to old plates of the Indian Atlas.				
25	...	...	34 H.	Hills being repaired.
28	...	...	166 H.	Heavy corrections and additions finished.
30	...	468	...	Corrections to outline and writing finished.
46	...	6,697	174 H.	Hills repaired; writing being recut.
47	...	...	202 H.	Hills being repaired.
65	...	...	44 H.	
94	...	...	...	Corrections to outline and writing in progress.
102	...	480	...	Slight additions completed.
Total .	...	7,645	560 H.	
New Plates Projected, Borders Cut, &c.				
11 N.E.	...	...	...	Projected.
11 N.W.	...	...	...	Ditto and border cut.
11 S.E.	...	..	...	Ditto ditto.
15 N.E.	...	1,833	...	Border, scale, and outside figures cut.
15 S.E.	...	1,535	...	Border and outside figures cut.
25 S.E.	...	...	...	Projected.
26 N.E.	...	...	...	Ditto and border cut.
Carried over .	...	3,368	...	

ENGRAVING OFFICE, CALCUTTA.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. In.	Letters cut.	Sq. In.	
New Plates Projected, Borders Cut, &c.—contd.				
Brought forward .	...	3,368	...	
26 S.E.	...	...	...	Projected and border cut.
30 N.E.	...	...	...	Ditto.
30 N.W.	...	...	...	Ditto.
30 S.E.	...	1,236	...	Ditto border and outside figures cut.
30 S.W.	...	...	...	Ditto.
47 N.E.	...	...	...	Ditto.
47 N.W.	...	...	...	Ditto.
47 S.E.	...	...	...	Ditto.
47 S.W.	...	1,329	...	Ditto, border, scale and outside figures cut.
Total .	...	5,933	...	

Abstract of work completed and in progress.

Engraving.

	Plates.
Atlas sheets completed	9
Ditto in progress in various stages	61
General maps, plans, &c. . . .	129
Repairs, corrections, and additions .	38
Projections engraved, borders cut, &c. .	16
Total .	253

Copper-plate printing.

Impressions taken	18,401
Proofs pulled	612
Transfers pulled	292
Total .	19,305

Steel-facing.

	Plates.
Double elephant plates steel-faced .	17
Ditto ditto steel removed	9
Quarter plates steel-faced . .	57
Ditto steel removed . . .	81
Miscellaneous plates steel-faced .	34
Ditto steel removed .	18
Total .	216

Square inches of hill etching . .	1,552
Ditto of jungle etched . .	57
Ditto of outline . . .	2,727
Number of letters engraved . .	324,589

Extract from the Report of Lieutenant-Colonel J. Waterhouse, S.C., *Assistant Surveyor General, in charge Photographic Office,—Season 1885-86.*

Out-turn.—Although there is a slight falling off in some items from the very large out-turn of last year, the work of the office generally, especially in the Zinc-printing Section for the ordinary departmental and extra departmental work, shows a large increase. The number of subjects received from other departments shows a falling off, though the number of printed copies is greater. The Cadastral work is well up to the average, the number of sheets reproduced being larger than last year, but the number of printed copies is less.

Original Subjects.—The number of subjects received for reproduction in the various sections of the Normal Establishment amounted to 1,518, of which 892 were departmental and 626 extra-departmental, as against 853 departmental and 849 extra-departmental of last year. The number of Cadastral sheets reproduced was 5,203, of which 3,387 were original drawings reproduced by photo-zincography and 1,818 transfer tracings for zincography.

Negative Section.—The number of negatives of departmental and extra-departmental work taken in the Normal Establishment, including 70 reversed negatives and transparencies required in the Photo-Collotype and Heliogravure Sections, was 2,671, or 98 more than last year. Mr. Turner took a series of negatives on dry plates of the interior of the Mint and also several photographs of objects of Indian art, the Bengal screens, Bamboo and Forest trophies and other exhibits going to the Indo-Colonial Exhibition, for the Revenue and Agricultural Department and the Government of Bengal. The number of negatives taken of Cadastral sheets was 3,387, or 103 less than last year.

The processes in this section have not been changed. The new method of intensification with sulphate of copper and bromide of potassium, followed by treatment with nitrate of silver, noticed in the Report for last year, has been in use all the year and proved satisfactory, as regards density, clearness of detail and keeping properties of the negatives,

and has been definitely adopted for all the ordinary work. The expense for chemicals is considerably greater than with the old system of intensifying with bichloride of mercury, followed by treatment with hyposulphite of soda and ammonia, but the results are better in many ways, and Mr. J. Mackenzie reports that the new system has the very great advantage, that the glasses are not stained, as they are with the bichloride of mercury, and can be used over and over again without fear of traces of old work appearing.

PHOTO-TRANSFER SECTION.—The total number of photo-transfer prints produced was 5,812, of which 2,320 were departmental and extra-departmental maps, &c., and 3,492 were Cadastral sheets. Last year the total number of prints was 5,900. No change has been made in the processes in this section.

ZINC-PRINTING SECTION.—The number of plates printed off by the Normal Establishment was 823, the number of pulls being 151,801 and of copies 267,989. The printing work is much in excess of last year, the number of pulls then being 121,909 and of copies 159,370. The increase is chiefly in departmental work. The presses in the Normal Establishment have all been fully worked every day throughout the year.

The number of sheets printed off by the Cadastral Establishment was 5,282 and the number of copies 144,760. Though 122 sheets more were printed off than last year, the number of copies printed is much less. This is owing to the increase in the number of North-West Provinces sheets, of which only 12 copies each are printed, while the Bengal and Burma sheets, of which 40 and 34 copies each are printed, have decreased.

SILVER-PRINTING SECTION.—The number of prints produced in this section during the year was 5,399 and exceeds by 1,493, the unusually large out-turn of last year. The principal item is an extensive series of large prints from the sketches in neutral tint made by Major E. L. Durand with the Afghan Boundary Commission. A great deal of work was also done for the Governments of India and Bengal in connection with the photographs taken by Mr. Turner of the exhibits for the Indo-Colonial Exhibition and of the former series of photographs made in the Calcutta Exhibition. Prints were also taken from a large number of dry plate negatives taken by Mr. C. L. Griesbach, of the Geological Survey, attached to the Afghan Boundary Commission.

PHOTO-COLLOTYPE SECTION.—The out-turn of this section has been 4,880 copies from 43 plates. This is not quite so much as last year, but the results have been much better; there is more certainty in working during the hot and rainy seasons, and the process is becoming one of the recognized means of reproducing ordinary photographs required for the illustration of the Archæological Survey and other Reports and for book illustrations.

Mr. Haward has paid a good deal of attention during the year to various methods of obtaining collotype or grained transfers from half-tone negatives suitable for printing from stone or zinc. Such prints, though not so delicate and perfect in gradation as collotype prints, are more easily and quickly produced and are consequently cheaper. The most successful results were obtained from transfers from collotype plates especially prepared with chloride of calcium in order to give a clear open grain. The process is, however, so delicate and requires such care in giving the collotype plates just the proper amount of softness to give the required grain that it seems unlikely to answer practically in this country.

Trials have also been made, but not as yet very successfully, with the somewhat similar process invented by Sergeant-Major Husband, R.E.., of the School of Military Engineering at Chatham, in which, instead of a collotype-plate and reversed negative being necessary, common salt is added to the gelatine used for coating ordinary photo-lithographic transfer paper as well as to the sensitising solution of bichromate of potash, and the transfer is printed in the usual way from any ordinary negative. After exposure the print is wetted and is then found to be covered with a fine vermicular grain very similar to that produced on collotype plates. It is then inked in while damp, with a glue-roller, and the result is a transfer print with a very delicate graduated grain. The best results are produced by transferring to a polished stone. I saw the process working at Chatham when on furlough and have been trying it again since my return. If this or some similar process could be worked successfully all through the year, it would be exceedingly valuable as a cheap and speedy means of printing half-tone subjects and has many advantages over collotype for that purpose, though the results would never be quite so good.

HELIOGRAVURE SECTION.—Owing partly to my absence during the greater part of the year and to the fact that the work of reproducing the negatives of art objects from the Calcutta Exhibition was discontinued under the orders of Government, there has not been so much work done as would otherwise have been the case. The principal feature of the work done during the year in this section has been the extension of electrotyping for the duplication of the engraved copper plates of the Indian Atlas and other standard maps. Three quarter-sheets of the Atlas and one double-elephant sheet of the 32-mile map were duplicated, and matrices taken of three other quarter-sheets of the Atlas and one sheet of the 32-mile map. The process seems likely to be of great service to the Engraving Office in enabling incomplete sheets, or sheets for which accurate surveys do not exist, being filled in temporarily for immediate issue without engraving on the original plates. In the same way the 32-mile Map of India may be temporarily completed on the duplicated plates pending completion from survey results. The whole of the work has been done with the

simple Vienna batteries described in earlier Annual Reports, and they have been found to answer perfectly well for the large double-elephant sized plates, the deposit being very regular and good in quality. Cow-hide of local manufacture is used for the porous cells.

Experiments have also been made by Mr. Turner with the object of obtaining transfers of half-tone subjects to zinc or stone from photo-engraved plates prepared so as to give a much stronger grain than is necessary for printing in the copper-plate press. Two plates were successfully transferred to stone for the illustration of the Archæological Survey Reports, and the method is perhaps more likely to be successful and give better results than the paper or collotype-grained transfers tried in the Photo-collotype Section, though it is more complicated and expensive.

A photo-electrotype plate is prepared in the way described in the Annual Report of the Survey of India for 1881-82 (Appendix, page 99), but using well-washed graining sand stearined with 8 grains of stearine to the ounce of sand. This gives a coarser grain than the stearined-washed flour emery powder. A thin negative is best so that a thin gelatine relief may be obtained through which the sand may thoroughly penetrate and give a good open grain. The deposit of copper need not be so thick as for copper-plate printing, and eight or ten days in the battery are sufficient. After coming out of the battery the plates require a careful cleaning up to bring out the grain well.

At the beginning of the year a few photo-engraved plates were done for the Revenue and Agricultural Department and sent home to Mr. W. Griggs for illustration of the *Indian Art Journal*. Two very successful plates of archæological drawings in pen and ink were also done for Dr. Burgess. The drawings were exceedingly fine to begin with, but they stood a very considerable reduction without any blocking up of the lines, which would have been impossible by photo-zincography.

The photo-etching process has also made some progress during the year, and Mr. Turner has tried several ways of getting a stronger grain so as to overcome the difficulty there is in printing the very delicate half-tones. He found that by using powdered resin, instead of asphaltum, the grain was stronger and stood the biting with perchloride of iron better.

A few type blocks have also been produced by the gillotype method of etching on zinc with nitric acid.

INDO-COLONIAL EXHIBITION.—Besides the special work done for the Revenue and Agricultural Department and Government of Bengal on account of the Indo-Colonial Exhibition, a series of exhibits illustrating the different processes worked in the office was prepared and included specimens of photo-zincography as applied to extra-departmental work, photo-engraving by the etching and electrotype processes, photo-collotype and silver-printing.

FURLOUGH.—I was compelled by ill-health to take furlough at the commencement of the hot weather in March and did not return until the middle of December. Lieutenant-Colonel W. F. Badgley had charge of the office during the greater part of my absence. During the first few months of the period under report, until I went on furlough, I was fully occupied, both in the Lithographic and Photographic Offices, with work of various kinds in connection with and preparation for the Indo-Colonial Exhibition, as well as preparing for the introduction of the new system of payment for work done for other departments. I was thus able to give little or no personal attention to the development of new processes.

During my stay in Europe I took the opportunity of re-visiting the Military Geographical Institute at Vienna and of visiting the new Topographical Depôt and the School of Roads and Bridges at Paris. I spent two or three days at the Ordnance Survey Office, Southampton, studying the new system of photo-zincographic work there and also the arrangements for electrotyping by means of the dynamo-electric machine.

I visited the School of Military Engineering at Chatham to see the working of Sergeant-Major Husband's process of Papyrotint. I made other enquiries about small motors for electro-typing, the air-brush, copying colored drawings with ortho-chromatic dry plates and other subjects connected with the working of the office, and was able to acquire some useful information, though the time I had at my command was very short, as most of my furlough had to be spent at health resorts on the Continent. A detailed report of my enquiries was submitted to the Secretary of State for India before I left England.

OFFICE ACCOMMODATION.—The pressing question of office accommodation again occupied a good deal of my attention during the early months of the year before I went on furlough. In consultation with the Government Architect the plans and estimates for the Photographic and Lithographic Offices were finally completed. On the occasion of the visit of the Hon'ble Sir S. C. Bayley, K. C. S. I., in January 1886, I drew up the following memorandum showing the inconveniences and deficiencies of the existing accommodation of these offices.

Memorandum on the existing Accommodation of the Photographic and Lithographic Offices, Calcutta, dated 28th January 1886.

These offices are located in three houses, *viz.*—

PHOTOGRAPHIC OFFICE.—Nos. 1 and 2, Wood Street.

PHOTOGRAPHIC OFFICE, CALCUTTA.

No. 1, Wood Street.—Office of Assistant Surveyor General in charge Lithographic and Photographic Offices; Negative and Transfer-printing Sections (Normal and Cadastral); Zinc-printing (Normal) 6 Presses; Silver-printing and Collotype-printing.

Private House.—Monthly rent R350+ R23-6-3 taxes (since raised to R31-7-8).

No. 2, Wood Street.—Zinc-printing (Cadastral) 11 Presses, Heliogravure (1 copper plate press) and Electro-typing Stores.

Private House.—Monthly rent R265 + R13-6 taxes (since raised to R23-13-6).

LITHOGRAPHIC OFFICE.—*No. 1, Camac Street* (lower floor). Lithographic, Drawing and Printing Sections (17 Litho. Presses and 1 Lithographic Machine), Type-printing (5 Presses and 1 machine in Mathematical Instrument Office).

Private House.—Monthly rent R300 + R20-1 taxes (since raised to R23-4).

Total annual rent for the three houses R11,661-15 (with extra taxation it now amounts to R11,923)

2. The objections to the present location of the Lithographic and Photographic Offices are as follow:—

(I) The division of these offices, which are both under my charge, in three separate buildings, one of them at some distance from the others, is excessively inconvenient, necessitating references and visits to and fro, and rendering efficient supervision difficult. The zincographic and lithographic presses, all doing similar work, are scattered between the three houses, in small rooms; those in No. 2, Wood Street, very dark and crowded; effective and constant supervision by the assistants in charge is impossible. Were they brought together, as proposed in the new buildings, there would be less loss of power and better work could be done by the use of stone or zinc, as might be best suited to the particular class of work required. The staff being concentrated could work together to better advantage, and the whole would be more effectively superintended. This is a reform I have long wanted to introduce.

(II) The present accommodation in private dwelling houses is quite unsuitable for such special technical work and processes. It is difficult to make proper provision in hired houses for the water-supply and the heating and drying arrangements necessary for our photographic work. Most of these houses are very badly built—No. 2, Wood Street particularly so, and it was much shaken by the earthquake which occurred in July 1885. The upper floors will carry no weight, and even the lower floors in some of the houses are not strong enough for heavy presses. It is true we have carried on for many years, but these defects have added greatly to our difficulties and stopped improvements. To have to go on working year after year in a makeshift manner without suitable arrangements, must inevitably tend to make the skilled assistants lose heart in their work.

(III) The photographic glass-house was built in 1869 to last for three years, in the hope that new buildings would be ready then. It is now very much cracked and has had to be shored up. The rooms are small and unsuitable for Europeans working in the hot weather, especially with the large plates we now use. The touching up and finishing of the negatives has to be done in an open shed exposed to the weather and dust. There is no proper place for keeping negatives.

(IV) For want of proper store-rooms, the photographic chemicals and stores are scattered between Nos. 1 and 2, Wood Street. There is no suitable place for storing apparatus out of use, and it is difficult to keep things in proper order and avoid loss and waste by spoiling.

(V) The silver-printing rooms are in an old cook-house, very damp and close to a drain which is often very offensive. The accommodation is quite unsuitable for the work.

(VI) In the Lithographic Office the space for the type composing and printing is very cramped and unsuitable. The type-printing machine has to be worked by the Mathematical Instrument Office. Both it and the lithographic printing machine could easily be worked by a small engine, but it is impossible to set up such machinery in a dwelling-house. In this office also the space for stores and records is very insufficient and unsuitable.

3. The actual want of space is not so much to be complained of at present, especially in the Photographic Office, as the general unsuitability of the accommodation for the purposes of work-rooms.

4. Nothing can be done to relieve the Photographic Sections of the offices until the new Mathematical Instrument Office is completed, and that building must therefore be taken in hand first. But if money were available a commencement might also be made of the new block for the Lithographic Office and zinc-printing rooms, which could be built immediately to the south of the dividing wall between No. 9, Park Street, and No. 13, Wood Street, without interfering with the work of other offices. If this were done, the two houses, No. 1, Camac Street, and No. 2, Wood Street, could be given up. The Photographic Office would remain in No. 1, Wood Street until the remaining block of new buildings could be built on the site of the present Mathematical Instrument Office. This latter building is very old and shaky and also quite unfitted for a machine factory."

5. While fully appreciating the financial difficulties which beset the Government at the present moment, I really think that this important question which has been under consideration for the past 15 years, should be dealt with without further delay if it is possible by any means to do so. The plans, as now designed, have been brought within the sanctioned estimates, though they barely do more than cover present requirements.

PHOTOGRAPHIC OFFICE, CALCUTTA.

Statement showing Expenditure (Dr.) and Value of work done (Cr.) during the Survey year, from 1st October 1885 to 30th September 1886.

Dr.				Cr.			
	R. a. p.				R. a. p.		
Normal Establishment.							
Superintendent's salary .	5,444 1 6			Departmental maps and plans	52,502 12 11		
Assistant Superintendent's salary	2,000 0 0			Miscellaneous maps and plans, Extra-departmental .	27,749 7 0		
		7,444 1 6				80,252 3 11
Establishment . . .	32,150 5 0			Cadastral maps, North-West Provinces . . .	35,470 2 0		
Rent of offices and taxes .	4,502 15 6			Ditto British Burma	25,949 0 0		
Contingencies . . .	2,586 9 11			Ditto Assam . .	11,475 0 0		
		39,239 14 5		Ditto Bengal . .	721 12 0		
						73,615 14 0	
Cadastral Establishment.							
Superintendent's salary .	5,444 1 6			Old tin and packing cases sent to the Mathematical Instrument Office . .	257 9 0		
Assistant Superintendent's salary	2,000 0 0			Articles and stores supplied to other offices . .	50 1 0		
		7,444 1 6				307 10 0	
Establishment . . .	33,056 15 0			Sale of unserviceable articles	147 10 9		
Office-rent and taxes .	3,351 7 5			Pure silver recovered from silver residues . .	2,187 12 10		
Contingencies . . .	7,400 2 3					2,335 7 7	
		43,808 8 8					
Chemicals and stores received from England . .	14,669 2 3						
Paper received from England	47,271 9 6						
		61,940 11 9					
Stores and materials received from the Stationery Office	518 13 4			Printing paper supplied to Litho. Office . .	1,638 12 0		
Printing paper and cloth received from Stationery Office	2,446 0 0					1,638 12 0	
		2,964 13 4				1,58,149 14 6	
Stores received from the Medical Store Department .	81 13 0			Balance against the Department	...	7,972 11 3	
Work done by Her Majesty's Mint	46 0 0						
Work done by the Foundry and Shell Factory . .	56 9 7						
		184 6 7					
Stores received from the Mathematical Instrument Office . .	418 5 0						
Cost of repair of articles at Mathematical Instrument Office	91 11 0						
		510 0 0					
Cost of type transfers supplied from Litho. Office . .	2,586 12 0						
		2,586 0 0					
Total .	...	1,66,822 9 9		Total .	...	1,66,122 9	

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Number of Sheets or Subjects.	Negatives. Number of Negatives (Direct).	Negatives. Number of Negatives reversed and transparencies.	Photozincographic Printing. Number of Photo-transfer Prints.	Photozincographic Printing. Number of Zinc Plates transferred.	Photozincographic Printing. Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
		M. I.	M. I.								
General Maps.											
Afghanistan and adjoining Country	Order completed	...	...	...	...	...	...	...	2	150	150
Burma and Regions adjacent	Do.	32=1	32=1	1	4	...	6	1	6	575	575
India shewing Railways open to Traffic, under Construction, and Survey	Negative and transfer taken last year. Order completed.	...	...	...	...	...	...	...	1	50	50
India, shewing Feeders to Railways	Order completed	32=1	32=1	6	14	...	14	6	6	600	600
Railway Map of India	...	...	...	...	...	...	...	...	34	3,800	3,600
Skeleton Map of India	Order completed	32=1	½ & ¼	6	12	...	12	3	1	250	250
Do. do. with Military Posts and Railways	...	32=1	32=1	2	20	...	20	5	5	110	110
Skeleton Map of Eastern Afghanistan and Punjab	Negatives and transfers taken. Printing in progress.	...	...	3	3	...	3	2	...	...	...
Skeleton Map of Burma and Assam											
Do. of Baluchistan and Sind											
Territories of H. H. the Khan of Khelat	...	...	...	...	...	...	...	...	4	160	160
Total	...	...	...	18	53	...	55	17	59	5,695	5,495
Provincial Maps.											
Central Provinces	Order completed	32=1	32=1	1	2	...	2	2	1	270	270
Do.	...	16=1	32=1	2	2	...	2	...	...	...	...
Total	...	...	...	3	4	...	4	2	1	270	270
Divisional Maps.											
British Burma, Pegu Division	Order completed	...	...	...	...	...	...	...	4	200	200
District Maps.											
Bannu, Dehra-Ismail-Khan, Delhi, Gurdaspur and Umballa	Order completed	...	...	...	...	...	...	...	3	1,400	5,400
Garo Hills, Lower Assam	Ditto	2=1	4=1	1	4	...	4	1	1	150	150
Bahraich, Chota-Nagpur, Dehra-Ghazi-Khan, Ferozepur, Gujranwala, Hooghly, Jhang, Jowanpur, Kamrup, Kohat, Lohardugga, Lucknow, Midnapur, Nowgong, Seoni and Sunderbuns	Ditto	4=1	4=1	13	39	...	39	12	12	2,170	7,170
Amritsar, Bannu, Gujrat, Hoshiarpur, Lahore, Ludhiana, Peshawar, and Shahabad.	Negatives and transfers taken. Printing in progress.	4=1	4=1	8	30	...	30	9	...	...	...
Betul, Bhandara, Darrang, Dehra-Dun, Goalpara, Mandla, Naga Hills, Nagpur, Nimar, Raipur, Sibsaugor, Shahpur, and Sultanpur	Ditto	4=1	8=1	13	13	...	13	3	...	...	...
Balaghat, Bilaspur, Cooch-Behar, Damoh, Gonda, Hoshungabad, Khoolna, Maldah, Midnapur, Mirzapur, Narsinghpur, Nuddea, Patna, Pilibhit, Rae-Bareilly, Shahabad, Singhboom and Sonthal Parganas.	Ditto	4=1 6=1 8=1	8=1	19	17	...	16	4	...	...	...
Bankoora, Chittagong, and Rungpore	Order completed	8=1	8=1	2	2	...	2	1	1	1,000	3,000
Kathiawar	Ditto	10=1	10=1 16=1	2	5	...	1	2	2	540	1,080
Alighur, Allahabad, Amritsar, Backergunge, Bareilly, Cawnpore, Chittagong Hill Tracts, Chumparun, Gujrat, Gurgaon, Hissar, Hoshiarpur, Jhansi, Jullundur, Kangra, Karnal, Kumaon, Lalitpur, Lahore, Mainpuri, Multan, Partabgurh, Peshawar, Pilibhit, Purnea, Rohtak, Sialkot, and Simla.	Negatives and transfers taken last year. Order completed.	...	...	...	...	...	...	...	11	7,350	26,350
Total	...	...	...	58	110	...	105	32	29	12,610	43,150
Plans of Cities and Cantonments.											
City of Mysore and Environs	Order completed	1=12	1=12	6	24	...	24	6	6	600	600
Hutted Camps Khyra Gully, Chungla Gully, Bara Gully, Kalabagh, Jhobba, Ghoradhaka and Kunja Gully.	Ditto	1=12	1=12	6	24	...	24	6	6	120	120

OFFICE, CALCUTTA.

1st October 1885 and 30th September 1886.

Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.			
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.	Value.	Remarks.
										R a. p.	
...	...	...	...	...	...	...	...	...	...	19 7 3	Reprint.
...	...	...	...	...	...	...	...	...	...	190 1 0	
...	...	...	...	...	...	...	...	...	...	10 9 0	
...	...	...	...	...	...	...	...	...	...	379 5 8	
...	...	...	...	...	...	...	...	...	...	975 5 6	Ditto.
...	...	...	...	...	...	...	...	...	...	223 14 6	
...	...	...	...	...	...	...	...	...	...	297 3 2	
...	...	...	...	...	...	...	...	...	...	49 3 2	
...	...	...	...	...	...	...	...	...	...	59 2 0	Ditto.
...	...	...	...	...	...	...	...	...	...	2,204 3 3	
...	...	...	...	...	...	...	...	...	...	62 11 9	
...	...	...	...	...	...	...	...	...	...	23 4 7	
...	...	...	...	...	...	...	...	...	...	86 0 4	
...	...	...	...	...	...	...	...	...	...	45 7 9	Ditto.
...	...	...	...	...	...	...	...	...	...	188 10 4	Ditto.
...	...	...	...	...	...	...	...	...	...	76 10 8	
...	...	...	...	...	...	...	...	...	...	947 2 7	
...	...	...	...	...	...	...	...	...	...	384 4 0	
...	...	...	...	...	...	...	...	...	...	155 3 7	
...	...	...	...	...	...	...	...	...	...	211 7 11	
...	...	...	...	...	...	...	...	...	...	142 15 8	
...	...	...	...	...	...	...	...	...	...	109 2 7	
...	...	...	...	...	...	...	...	...	...	709 0 2	
...	...	...	...	...	...	...	...	...	...	2,924 9 6	
...	...	...	...	...	...	...	...	...	...	448 7 0	
...	...	...	...	...	...	...	...	...	...	322 2 2	

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map.		Number of Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct).	Number of Negatives reversed and transparences.	Number of Photo.-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
		M. I.	M. I.								
Plans of Cities and Cantonments—*contd.*											
Ajmere City and Environs, sheets 1 to 5	Order completed	1=12	1=12	1	1	...	5	1	5	250	250
Simla, Revised Map, sheets 1 to 4, 6 to 8, 12 and 13.	Negative and transfer taken. Printing in progress.	1=24	1=24	9	36	...	36	9	...	...	...
Saugor City and Cantonment	Order completed	1=8	1=6	4	8	...	8	2	2	300	300
Benares City, 3rd portion (in duplicate)	Negative and transfer taken only.	1=16	1=16	2	4	...	4	2	...	...	...
Bhuj City and Cantonment	Order completed	1=12	1=12	7	14	...	14	7	7	1,050	1,050
Dalhousie Sanitarium	Negative and transfer taken. Printing in progress.	1=10	1=6	4	4	...	4	1	...	...	...
Dungarpur and Environs, and Cantonment of Kherwara.	Ditto.	...	Scale	2	8	...	8	3	...	...	...
City of Baroda, sheets 1 to 16	Ditto.	...	Scale	46	31	...	29	16	...	...	...
Total		...	...	57	154	...	156	53	26	2,320	2,320
Indian Atlas.											
Sheet 47, N.W. and S.W.		...	...	...	...	...	...	1	1	...	...
Full sheet 47		4=1	4=1	1	6	...	10	1	...	...	...
Quarter-sheet 4 N.W.		4=1	4=1	1	2	...	2	1	1	3	3
Ditto. 4 S.E.	Only three tracing Prints taken.	...	...	...	...	...	...	...	1	100	100
Total		...	...	2	8	...	12	3	3	103	103
Standard Maps.											
Andaman Survey—											
Sheets 8 (12, 20), 13, 14, 15		1=4	1=4	9	24	...	24	6	6	850	850
Assam Survey—											
Sheet 30		...	1=2	...	...	...	...	...	1	50	50
Baluchistan Survey—											
Sheets 29 N.E./3, N.W./4, S.E./3, S.W./3, 30 N.W./13, S.W./1		2=1	2=1	7	28	...	28	6	2	300	300
Bengal Survey—											
Tirhoot District, Chukla Girjaul, Pargana Bisara		...	...	...	...	...	...	1	1	200	200
Pargana Gudehsur		1=1	1=1	1	1	...	1	1	1	200	200
Tirhoot, Mozufferpore and Durbhunga, Pargana Maps of		1=1	1=1	5	13	...	13	...	...	...	...
Tirhoot District, Parganas Hajeepore and Ruttee		1=1	1=1	2	6	...	6	2	2	400	400
Mozufferpore, sheets 112 and 113		...	...	...	...	...	...	...	2	560	560
Durbhunga, sheets 143, 144, 170 to 173, 199, 200		...	...	...	...	...	...	...	8	2,240	2,240
Mozufferpore and Durbhunga, 114 and 145		...	...	...	...	...	...	...	2	560	560
Tirhoot District, Pargana Gurh Chawand and Burail, Jahangirabad and Kasma, Saraisa, District Mozufferpore and Durbhunga		...	...	...	...	...	...	4	...	...	...
Burma Survey—											
Bassein District—											
Sheets 104 S.E., S.W.; 112 N.E., N.W., S.E., and S.W.	Negatives and transfers taken last year. Order completed.	...	..	...	...	...	...	15	15	2,250	2,250
Sheets 113 N.E., N.W., S.E., S.W.											
,, 121 N.E., N.W., S.E.											
,, 122 N.W. and S.W.											

OFFICE, CALCUTTA.

1st October 1885 and 30th September 1886.

Silver and other Printing.			Heliogravure & Electrotyping.					Photocollotype.			
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.	Value.	Remarks.
										R a. p.	
...	...	...	...	...	...	...	...	...	...	138 14 1	
...	...	...	...	...	...	...	...	...	...	475 3 2	
...	...	...	...	...	...	...	...	...	...	193 14 5	
...	...	...	...	...	...	...	...	...	...	54 0 0	Plate cancelled.
...	...	...	...	...	...	...	...	...	...	385 10 2	
...	...	...	...	...	...	...	...	...	...	53 1 7	
...	...	...	...	...	...	...	...	...	...	117 9 7	
...	...	...	...	...	...	...	...	...	...	464 1 7	
...	...	...	...	...	...	...	...	...	...	2,652 15 9	
...	...	...	...	...	...	...	...	...	...	8 12 0	Plate cancelled.
...	...	...	...	...	...	...	...	...	...	97 3 0	Including four Transfers for Litho: office.
...	...	...	...	...	...	...	...	...	...	36 7 0	
...	...	...	...	...	...	...	...	...	...	18 1 4	
...	...	...	...	...	...	...	...	...	...	160 7 4	
16	...	...	...	...	...	...	...	...	...	587 10 1	
...	...	...	...	...	...	...	...	...	...	14 3 1	
...	...	...	...	...	...	...	...	...	...	432 3 11	
...	...	...	...	...	...	...	...	...	...	49 6 1	
...	...	...	...	...	...	...	...	...	...	36 9 5	
...	...	...	...	...	...	...	...	...	...	168 0 0	
...	...	...	...	...	...	...	...	...	...	153 11 2	
...	...	...	...	...	...	...	...	...	...	139 6 7	
...	...	...	...	...	...	...	...	...	...	632 13 0	
...	...	...	...	...	...	...	...	...	...	163 6 9	
...	...	...	...	...	...	...	...	...	...	25 0 0	
...	...	...	...	...	...	...	...	...	...	601 8 4	Including the cost of 18 Tracing Prints.

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map.		Number of Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct).	Number of Negatives reversed and transparencies.	Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
		M. I.	M. I.								
Standard Maps—*contd.*											
***Burma Survey*—contd.**											
Districts Pegu and Hanthawaddy— Sheets 127 N.E., N.W., and S.W.. „ 115 N.E., N.W., S.E., and S.W. Sheets 128 N.E., N.W., S.E., and S.W. Sheets 96 N.E. and S.E.; 97 N.E. „ 98 S.E.; 112 N.W. and S.W. Sheets 114 N.E., N.W., S.E. and S.W.		1=2	1=2	7	28	...	25	7	17	459	459
District Tharrawaddy— Sheets 76 N.E., N.W., S.E., and S.W. Sheets 76 $\frac{S.E.}{4}$; 77 $\frac{S.W.}{3}$; 93 S.W.. „ 95 N.E., N.W., S.E. and S.W.		1=2 1=4	1=2 1=4	11	44	...	44	10	4	108	108
District Prome— Sheets 61 and 93 „ 77 $\frac{N.E.}{1·3}$; 93 $\frac{N.E.}{1·3}$; 94 $\frac{S.E.}{2}$ $\frac{N.E.}{4}$ 110 $\frac{S.W.}{1}$, $\frac{N.W.}{1·2}$ Sheets 123 and 111 N.W. „ 125 „ 93 $\frac{N.E.}{2·4}$, $\frac{S.E.}{1·2·3·4}$ 94 $\frac{N.E.}{2}$ „ 92 $\frac{S.E.}{3·4}$; 94 $\frac{S.E.}{4}$ and 110 $\frac{S.W.}{3}$	Sheets 94 $\frac{S.E.}{4}$ and 110 $\frac{S.W.}{3}$ are printed off. Rest in progress.	1=2 1=4 1=2 1=2 1=4	1=1 1=4 1=2 1=2 1=4	8 8 2 4 9	8 32 8 16 36	... ...	8 28 8 8 40	2 17 3	 2	 300	 300
***Burma Topographical Survey*—**											
Sheet 95 $\frac{N.E.}{4}$		1=4	1=4	1	4	...	4	1	...	...	...
***Central India and Rajputana Survey*—**											
Sheets 148 and 149 „ 95 and 118		1=1 1=1	1=1 1=1	2 2	8 8	... ...	8 8	2 2	2 2	300 100	300 100
***Cutch Survey*—**											
Sheets, 26, 27, 28, and 29 „ 3, 4, 10, and 11 „ 33, 34, 35, and 69 „ 17, 18, 24 and 25		1=2 1=2 1=2 ...	1=1 1=2 1=1 ...	16 1 16 ...	20 4 16 ...	... ...	20 4 16 ...	4 1 4 ...	4 1 ... 1	600 150 ... 150	600 150 ... 150
***Deccan Survey*—**											
Sheets 64, 65, and 203		1=2	1=1	12	12	...	12	3	...	...	...
***Ghazipur District*—**											
Sheet 209 N. E., N. W., S. E. and S. W.		1=2	1=1	4	4	...	4	1	...	...	...
***Gujarat Survey*—**											
Sheets 41, 41 $\frac{N.E.}{2·4}$, $\frac{N.W.}{1·2}$, $\frac{S.E.}{1·2}$ „ 42 $\frac{N.W.}{1·2·4}$, $\frac{S.E.}{3}$, $\frac{S.W.}{1·2·3·4}$ „ 43 $\frac{N.W.}{1·2·3·4}$, $\frac{S.W.}{1·2·3·4}$ „ 50, Sections 5, 7, and 9 „ 15 „ 1, 2, and 3 „ 35 „ 1, 2, 3, and 4 „ 36 „ 1, and 2 „ 15 and 184 „ 44 „ 36 $\frac{N.E.}{4·4}$ and $\frac{S.E.}{2}$ „ 50, Sections 6 and 8		1=4	1=4	25	100	...	92	25	25	3,750	3,750
		1=2	1=2	6	24	...	24	7	7	1,050	1,050
		1=2	1=2	2	8	...	8	2	2	300	300
		1=2	1=1	1	5	...	5	1	2	300	300
		1=2	1=1	4	4	...	4	1	...	...	...
		1=4	1=4	5	20	...	20	4	1	150	150

OFFICE, CALCUTTA.

1st October 1885 and 30th September 1886.

Silver and other Printing.			Heliogravure and Electrotying.					Photocollotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	713 1 11	
...	...	...	...	...	...	...	...	...	...	621 9 10	
...	...	...	...	...	...	...	...	...	...	113 1 7	
...	...	...	...	...	...	...	...	...	...	455 6 5	
...	...	...	...	...	...	...	...	...	...	114 9 7	
...	...	...	...	...	...	...	...	...	...	145 3 2	
...	...	...	...	...	...	...	...	...	..	516 7 1	
...	...	...	...	...	...	...	...	...	...	54 0 0	
...	...	...	...	...	...	...	...	...	...	191 8 0	
...	...	...	...	...	...	...	...	...	...	147 6 0	
...	...	...	...	...	...	...	...	...	...	434 1 0	
...	...	...	...	...	...	...	...	...	...	104 14 9	
...	...	...	...	...	...	...	...	...	...	211 3 1	
...	...	...	...	...	...	...	...	...	...	47 2 0	
...	...	...	...	...	...	...	...	...	...	175 0 0	
...	...	...	...	...	...	...	...	...	...	54 0 0	
...	...	...	...	...	...	...	...	...	...	2,363 8 0	
...	...	...	...	...	...	...	...	...	...	642 11 10	
...	...	...	...	...	...	...	...	...	...	209 13 5	
...	...	...	...	...	...	...	...	...	...	160 9 2	
...	...	...	...	...	...	...	...	...	...	52 12 9	
	...	...	...	...	...	...	...	...	...	307 4 0	

5

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map.		Number of Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct).	Number of Negatives reversed and transparencies.	Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
		M, I.	M. I.								
Standard Maps—*contd.*											
Gujarát Survey—contd.											
Sheets 18 and 37, Section 1		1=2	1=2	2	8	...	8	2	...	...	...
,, 18 and 13 ,, 2											
,, 18		1=2	1=1	4	4	...	4	1	...	...	...
,, 50 Supplement to Sections 1, 3, and 10		...	...	...	...	...	...	...	3	450	450
Hissar District→											
Sheets 242 S. E., 243 N. E., S. E.											
,, 257 N.E.,N.W.,S. E. and S. W.											
,, 258 N.E.,N.W.,S. E. and S. W.		1=2	1=2	23	92	...	92	23	23	3,450	3,450
,, 259 N.E.,N.W.,S. E. and S. W.											
,, 260 N.E.,N W.,S. E. and S. W.											
,, 261 N.E.,N.W.,S. E. and S. W.											
Hooghly River Survey—											
Sheet 1 Q R.											
,, 2, Sections C. D.											
,, 6 ,, A. D. E. F. G. H. I. K.											
,, 7 ,, C. D. E. F. G. H. I.		1=16	1=16	32	64	...	60	18	15	3,000	6,000
,, 7 ,, J. K. L. M. N.											
,, 8 ,, C. F. G. H. I. J. K. L.											
,, 6, 7, and 8		1=6	1=6	3	12	...	12	3	3	18	18
,, 4, 6, 7, 9 and 10		1=3	1=3	5	20	...	20	5	5	10	10
,, 1, 2, 3, and 4		1=8	1=6	8	16	...	16	4	4	600	600
,, 1, Sections L. M. N. O. P.											
,, 2 ,, A. B. E. F. G. H. I. J. K.											
,, 3 ,, E. and H.		1=16	1=16	32	33	...	32	33	...	...	...
,, 4 ,, H. I. J. K. L. M. N. O. P.											
,, 5 ,, E. J. K. L. O. P. and Q.											
,, 6 ,, B. C.											
,, 7 ,, A. B.											
,, 8 ,, A. B. D. E.											
,, 5 ,, A. B. C. D. F. G. H. I. M. N.		1=16	1=16	38	76	...	86	21	17	4,200	8,400
,, 9 ,, A. B. C. D. E. F. G. H. I.											
,, 3 ,, A. B. C. D. F. G. I. J. K.											
,, 4 ,, A. B. C. D. E. F. G.											
,, 1 and 2		1=6	1=6	2	8	...	8	2	2	300	300
,, 1, Sections A. and E., B. and P., D. and H., I. and K.		...	...	...	...	...	...	...	6	1,200	1,200
Hyderabad Survey—											
Daverconda Circar—											
Isolated portion of		1=1	1=1	2	6	...	6	2	2	150	150
Koilkondah Circar—											
Sheets (100, 101, 124, 125)											
,, (102, 103, 126, 127)		2=1	2=1	3	11	...	11	3	3	225	225
,, (104, 105, 128, 129)											
Moodgul Circar—											
Sheets 54, 55, 56, 57, 30, 31, 32											
,, (33 and 58), (82 and 108)		1=1	1=1	14	43	...	43	14	13	975	975
,, (53, 80, and 106), 80, 81, 83, 84											
Mulkaid Circar—											
Sheets (106, 130), (101, 102, 103, 125, 126, 127)		2=1	2=1	3	9	...	9	3	3	225	225
,, (104, 105, 128, 129)											
Yedgary Circar—											
Sheets (104 and 105)		1=1	1=1	1	3	...	3	1	1	75	75
Jullundur, Ludhiana and Kapurthala States—											
Sheets 251 N.E., N.W., S.E. and S.W.		1=2	1=1	4	4	...	4	1	1	150	150
Kathiawar Survey—											
Sheets 21 and 35											
,, 26, 28, 29, and 45		1=2	1=1	81	93	...	93	20	21	3,150	3,150
,, 6, 7, 9, 12, 15, 16, 17, 22, 24											
,, 27, 32, 33, 43, 52, and 53											

OFFICE, CALCUTTA.

1st October 1885 and 30th September 1886.

Silver and other Printing.			Heliogravure and Elrctrotyping.					Photocollotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo-Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	106 12 9	
...	...	...	...	...	...	...	...	...	...	52 12 9	
...	...	...	...	...	...	...	...	...	...	141 13 3	
...	...	...	...	...	...	...	...	...	...	2,262 12 9	
...	...	...	...	...	...	...	...	...	...	1,608 6 9	
...	...	...	...	...	...	...	...	...	...	161 1 3	
...	...	...	...	...	...	...	...	...	...	287 9 5	
...	...	...	...	...	...	...	...	...	...	358 11 9	
...	...	...	...	...	...	...	...	...	...	774 0 0	
...	...	...	...	...	...	...	...	...	...	2,093 3 7	
...	...	...	...	...	...	...	...	...	...	181 2 8	
...	...	...	...	...	...	...	...	...	...	227 10 0	
...	...	...	...	...	...	...	...	...	...	140 10 0	
...	...	...	...	...	...	...	...	...	...	239 7 3	
...	...	...	...	...	...	...	...	...	...	927 10 6	
...	...	...	...	...	...	...	...	...	...	210 10 0	
...	...	...	...	...	...	...	...	...	...	68 12 5	
...	...	...	...	...	...	...	...	...	...	95 12 0	
...	...	...	...	...	...	...	...	...	...	2,124 12 5	

PHOTOGRAPHIC

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map.		Number of Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct).	Number of Negatives reversed and transparencies.	Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
Standard Maps—*contd.*		M. I.	M. I.								
Kohat Survey— Sheet 7		1=1	1=1	1	4	...	4	1	1	150	150
Konkan Survey— Sheet 79 N.E./1, 2, 3, 4; N.W/1, 2, 3, 4; 80—N.E./1, 2, 3, 4; N.W.; S.E./1, 2, 3, 4; S.W./1, 2, 3, 4; 81 N.E./1, 2, 3, 4; N.W./2, 4; S.E./1, 2, 3, 4; S.W.; 2, 4; 82 N.E./1, 2, 3, 4; S.E./1, 2, 3, 4; 4A S.W./3; 4B S.E./1, 2, 3, 4; 7 N.E./3; N.W./1, 3; S.E./1, 2, 3, 4; S.W./1, 2, 3, 4; 7 A N.E./1, 2, 3, 4; N.W./1, 3; S.E./1, 2, 3, 4; S.W./1, 2, 3, 4; 79, 82, 135, 161.		1=2 / 1=4	1=1 / 1=2 / 1=4	53	134	...	134	53	42	6,541	6,541
Meerut Division— Alighar and Etah District— Sheet 52 N.E., N.W., S.E. and S.W.											
,, 53 N.E., N.W., S.E. and S.W.											
,, 37 N.W.											
Alighar District— Sheet 23 N.W., S.E.		1=2	1=2	11	44	...	44	11	4	600	600
,, 35 N.E., N.W., S.E., S.W.											
Mirzapur District— Sheet 186 N.E., N.W., S.E. and S.W.											
,, 187 N.E., 201 S.E., 202 N.E., N.W.	Order completed.										
,, 186, 187 and 200		1=2	1=2 / Half scale	6	24	...	26	8	9	1,350	1,350
Montgomery District— Sheets 147, 148 149, 150, 170, 171, 172 173, 175, 194, 195, 196, 197, 198, 211 and 212		...	..	..	...	...	...	...	16	4,480	4,480
Mysore Survey— Sheets 3, 22, 24, 25, 26, 42, 49, 51, 52, 53, 54, 58, 59, 60, 61, 62, 63, 64, 67, 68 and 69		1=1	1=1	12	48	...	48	14	14	1,950	1,950
North-East Trans-frontier— Sheets 14 N.W./3, 4; 14 N.W.; 7, 10, 11		...	...	...	...	...	...	3	6	900	900
,, 22 N.W.; N.W./1, 3		2=1 / 4=1	2=1 / 4=1	3	12	...	12	3	3	450	450
,, 22		8=1	8=1	1	2	...	2	1	1	50	50
North-West Trans-frontier— Sheet 29 S.E./1, 3; S.W.; 30 N.W./3; S.W./4		...	...	...	...	...	...	3	7	950	850
,, 28 N.W., (a portion only)		4=1	4=1	1	1	...	1	1	1	150	150
,, 20 S.E.; S.W.; 21 N.E.; N.W.; S.E.											
,, 22 N.E./2, 4; N.E.; 30 N.W./1, 3		...	...	...	...	...	...	...	19	1,000	850
,, 29 S.E./3; 28 N.E.; N.W.; 27 S.E.											
,, 30 N.W.; S.W. (Baluchistan)		4=1	4=1	1	8	...	8	2	2	300	300
,, 29 S.E.; S.E./3		2=1 / 4=1	Scale	2	8	...	8	2	2	300	300
Rawal Pindi Survey— Sheets 162 N.E./1, 2, 3, 4		1=4	1=4	4	8	...	8	4	...	...	...
,, 185 S.W./1, 2, 3, 4; 186 N.W./1, 2, 3, 4;		1=4	1=4	6	17	...	15	6	...	...	...
,, 160 N.E./2, 3, 4; S.E./3, 4; 161 N.E./2, 3; S.E./2											
,, 183 S.W./3; 186 S.W./1, 2, 3, 4		1=4	1=4	10	36	...	36	10	...	...	...
Total		...	...	538	1,329	...	1,315	410	359	52,676	59,626

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Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo-Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	83 2 0	
...	...	...	...	...	...	...	...	...	...	3,564 1 7	Including the cost of five Tracing Prints.
...	...	...	...	...	...	...	...	...	...	769 3 5	
...	...	...	...	...	...	...	...	...	...	739 9 9	
...	...	...	...	...	...	...	...	...	...	1,233 3 2	
...	...	...	...	...	...	...	...	...	...	1,230 5 3	
...	...	...	...	...	...	...	...	...	...	246 15 3	
...	...	...	...	...	...	...	...	...	...	308 2 9	
...	...	...	...	...	...	...	...	...	...	49 1 4	
...	...	...	...	...	...	...	...	...	...	208 35 0	
...	...	...	...	...	...	...	...	...	...	55 2 2	
...	...	...	...	...	...	...	...	...	...	195 14 1	Reprint.
...	...	...	...	...	...	...	...	...	...	195 1 7	
...	...	...	...	...	...	...	...	...	...	191 7 11	
...	...	...	...	...	...	...	...	...	...	147 8 0	
...	...	...	...	...	...	...	...	...	...	264 1 0	
...	...	...	...	...	...	...	...	...	...	486 4 9	
16	5	...	...	...	...	...	...	...	...	32,871 2 6	

Statement of Departmental Work done between

Specification of Peate or Print.	Progress made.	Scale of Map.		Number of Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct).	Number of Negatives reversed and transparencies.	Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
Index Maps.		M. I.	M. I.								
Rajputana		...	...	...	...	...	...	1	1	100	100
Dehra-Dun, Gorakhpur, Kamrup, and Sambalpur		...	...	...	...	...	...	...	3	1,550	2,200
North-East Trans-Frontier		...	...	...	...	...	...	...	1	100	100
Shwegyin District, Season's operations		4=1	Scale	1	1	...	1	...	2	34	34
South Maratha Survey		16=1	16=1	1	1	...	2	1	1	25	25
Ditto ditto		12=1	16=1	1	1	...	1	1	1	60	60
Trans-frontier of India		128=1	256=1	1	1	...	1	1	2	550	550[8]
Mozufferpore District		8=1	12=1	1	1	...	1	1	1	25	25
Punjab		...	...	...	...	...	2	1	1	1,050	550
North-West Trans-frontier		64=1	156=1	1	1	...	1	...	1	100	100
Ditto (Revised)		...	Reduced	1	1	...	1	1	...	...	...
H. H. the Nizam's Dominions		16=1	Reduced	2	2	...	2	1	1	50	50
Ditto ditto		16=1	32=1	2	2	...	2	1	1	50	50
Ditto Madras Sheet 1		32=1	64=1	1	1	...	1	1	...	...	...
Ditto Madras and Sindh Sheets 1 and 2		...	Scale	3	4	...	4	1	1	12	36
Ditto Madras and Sindh, Sheets 1 and 2		...	Reduced	3	3	...	3	1	1	50	150
North Trans-frontier and South-East Trans-frontier		...	...	...	...	...	2	2	...	...	...
Akyab, Andaman, Bassein, Cutch, Henzada, Hanthawaddy, Punjab, &c.		16=1	Scale	5	5	...	5	1	3	1,550	3,300
		16=1	24=1								
		18=1	36=1								
Ajmere, Basti, Burma, Garo, Khasi and Naga Hills and Merwara.		24=1	32=1	5	5	...	5	1	2	1,300	2,750
		4=1	6=1								
		12=1	24=1								
Akyab, Ajmere, Andaman, Bassein, Basti, Burma, Baluchistan, Cutch, Dehra-Dun, Deccan, Gorakhpur, Khasi and Garo Hills, Gujarat, Hanthawaddy, Henzada, Kamrup, Merwara, Mirzapur, Punjab, Rajputana, and Sambalpur.		...	...	...	...	...	...	...	9	650	1,050
Gujarat		24=1	32=1	1	1	...	1	1	2	775	550
Assam, Bengal, Burma and Punjab Provinces		24=1	50=1	4	4	...	4	1	4	1,060	1,240
			48=1								
			52=1								
Bengal and Punjab Provinces		...	...	...	...	...	1	1	1	50	100
Hooghly River Survey		25=1	4=1	1	1	...	1	1	1	50	50
Ajmere, Akyab, Bilaspur, Darrang and Kamrup		...	Reduced	3	3	...	3	1	...	...	...
		16=1	16=1								
Nepal Boundary		...	...	1	1	...	1	1	...	...	...
Deccan, Konkan, Mirzapur and Rajputana		16=1	Scale	3	3	...	3	3	3	1,550	2,200
		24=1									
		16=1	32=1								
Mozufferpore and Sambalpur		4=1	8=1	1	1	...	2	1	...	...	...
Andamans and South Maratha		16=1	24=1	1	1	...	3	1	...	...	...
Trans-frontier of India and North-West Trans-frontier		...	Reduced	2	2	...	2	1	...	...	...
Ajmere		4=1	6=1	1	1	...	1	1	...	...	...
Rajputana		24=1	24=1	1	1	...	1	...	1	150	150
Akyab, Basti, Deccan, Gorakhpur and Konkan		...	Scale	5	5	...	5	1	...	...	...
		...	Reduced								
Gujarat		...	Reduced	1	1	...	...	...	...	...	...
Cutch		16=1	32=1	1	1	...	...	...	...	...	...
Damoh and Jubbulpore District		8=1	12=1	1	1	...	...	...	...	...	...
Total		...	...	55	56	...	62	30	44	10,891	15,420
Technical Charts.											
Triangulation Charts of Bhopal and Malwa Survey and of North-East Frontier Survey, Degree Sheets XIV and XXV		4=1	4=1	2	4	...	4	2	2	50	50
Triangulation Chart of North-East Frontier Survey, Degree Sheet X.		...	...	...	...	...	...	...	1	25	25
Total		...	...	2	4	...	4	2	3	75	75
Miscellaneous Maps and Plans.											
Province of Assam, illustrating percentage under Rice, Tea, Mustard to Total Cultivation		...	...	...	...	...	...	5	6	1,053	1,053

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1st October 1885 and 30th September 1886—continued.

Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo-Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	13 12 10	
...	...	...	...	...	...	...	...	...	...	173 4 11	
...	...	...	...	...	...	...	...	...	...	11 9 5	
...	...	...	...	...	...	...	...	...	...	28 0 4	Including the cost of four tracing prints.
...	...	...	...	...	...	...	...	...	...	26 9 1	
...	...	...	...	...	...	...	...	...	...	17 0 0	
...	...	...	...	...	...	...	...	...	...	51 15 3	*Out of 550 copies 500 reprinted.
...	...	...	...	...	...	...	...	...	...	15 12 2	
...	...	...	...	...	...	...	...	...	...	94 0 2	
...	...	...	...	...	...	...	...	...	...	13 4 8	
...	...	...	...	...	...	...	...	...	...	13 2 0	Plate cancelled.
...	...	...	...	...	...	...	—	...	...	27 14 9	
...	...	...	...	...	...	...	...	...	...	37 2 3	
...	...	...	...	...	...	...	...	...	...	9 14 6	
...	...	...	...	...	...	...	...	...	...	60 0 9	
...	...	...	...	...	...	...	...	...	...	48 13 0	
...	...	...	...	...	...	...	...	...	...	14 1 7	Ditto.
...	...	...	...	...	...	...	...	...	...	220 5 10	
...	...	...	...	...	...	...	...	...	...	191 12 9	
...	...	...	...	...	...	...	...	...	...	59 5 0	Reprint.
...	...	...	...	...	...	...	...	...	...	71 3 9	
...	...	...	...	...	...	...	...	...	...	107 7 2	
...	...	...	...	...	...	...	...	...	...	8 10 0	
...	...	...	...	...	...	...	...	...	...	17 4 2	
...	...	...	...	...	...	...	...	...	...	38 0 0	
...	...	...	...	...	...	...	...	...	...	21 14 0	
...	...	...	...	...	...	...	...	...	...	212 8 9	
...	...	...	...	...	...	...	...	...	...	16 12 9	
...	...	...	...	...	...	...	...	...	...	28 3 2	
...	...	...	...	...	...	...	...	...	...	30 15 0	
...	...	...	...	...	...	...	...	...	...	13 12 9	
...	...	...	...	...	...	...	...	...	...	18 15 4	
...	...	...	...	...	...	...	...	...	...	58 6 9	
...	...	...	...	...	...	...	...	...	...	5 6 4	
...	...	...	...	...	...	...	...	...	...	5 1 7	
...	...	...	...	...	...	...	...	...	...	6 4 9	
...	...	...	...	...	...	...	...	...	...	1,788 11 6	
...	...	...	...	...	...	...	...	...	...	87 9 5	
...	...	...	...	...	...	...	...	...	...	13 6 1	
...	...	...	...	...	...	...	...	...	...	100 15 6	
...	...	...	...	...	...	...	...	...	...	205 14 8	

PHOTOGRAPHIC

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map.		Number of Sheets or Subjects	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct).	Number of Negatives reversed and transparencies.	Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
		M. I.	M. I.								
Miscellaneous Maps and Plans— *contd.*											
Bankoora and Manbhoom Districts—Main Circuit Maps, Nos. 7, 5 and 9, transferred to Burdwan District		1=1	1=1	3	11	...	11	3	3	450	450
Burdwan District—Main Circuit Maps, Nos. 1 to 10		1=1	1=1	12	32	...	32	12	12	1,800	1,800
North-West Frontier, country on either side of		32=1	32=1	1	6	...	6	3	3	74	74
Ditto		...	...	...	...	...	...	...	4	350	350
Baluchistan, portion of Sheet 29 N.W. and S.W.		4=1	3=1	1	1	...	1	1	1	1	1
Gujarat—											
Sheet 15, Sections 1, 2, 3		1=2	4=1	6	6	...	...	...	...	...	...
„ 35 „ 1, 2, 3											
Baila, route to and from		...	...	...	...	...	...	1	1	20	20
Graticule scales		...	Scale	1	1	...	1	1	1	80	80
Scale for reducing relative height		...	½ scale	1	1	...	1	1	1	20	20
Irrawaddy River		...	Scale	1	4	...	8	3	3	300	300
Explanation of signs and abbreviations		...	Do.	1	1	...	1	1	1	50	50
North-East Trans-frontier, Sheets 7, 10, and 11		...	½ scale	3	3	...	...	...	...	...	...
Specimen of Engraved Hill Shading		4=1	2=1	3	3	...	...	...	...	...	...
Sketch of Hill drawing for Model Map		...	Scale	1	1	...	1	1	1	50	100
Kohat Survey, Sheet 7		1=1	4=1	1	1	...	...	...	...	...	...
Mysore, Sheets 3, 51, 52, 53, 55, 58, 59, 60, 61, 62, 64, 67, 68, and 69		1=1	4=1	14	14	...	...	...	...	...	...
Mysore, part of Sheet No. 6		...	...	...	...	...	...	...	...	...	...
Contour Map of India		32=1	64=1	6	6	...	5	2	...	...	...
Photographic, Lithographic and Mathematical Instrument Offices Plans and General Block Plan		20=1	20=1	4	18	...	18	4	4	80	80
Ramsden's Zenith Sector		...	Reduced	1	2	...	...	...	...	...	...
Arabian Sea, Indian Ocean and Gulfs of Aden and Persia		...	½ scale	9	5	...	5	1	1	225	225
Map of India		128=1	96=1	1	1	...	1	...	...	...	...
Benares City, Skeleton Map of		32=1	8=1	1	1	...	...	...	...	...	...
Kwin Maps, 16", Titles for		...	Scale	32	4	...	4	1	1	90	957
Mandalay, Map of various Military reconnoissances in the neighbourhood of		2=1	2=1	1	4	...	4	1	1	250	250
Specimens showing borders, scale 2=1, 1=1		1=1	Scale	3	8	...	8	1	1	400	400
Star Finder (Diagram)		...	½ scale	1	1	...	1	1	1	12	12
Kumaon and British Gurhwal, Sheet 1, (a portion)		1=1	1=1	1	1	...	...	...	...	...	...
Rajputana, sheets 148 and 149		1=1	4=1	2	2	...	...	...	...	...	...
Gwalior and Central India, sheets 85 and 99		1=1	4=1	2	2	...	...	...	...	...	...
Chart of the Suakim Survey and Reconnoissance Map of Country near Suakim		1=2 1=4	Scale	2	8	...	8	2	2	75	75
Triangulation Chart Suakim Survey		...	...	...	...	...	...	...	1	5	5
Burma—											
Sheets 92 S.E., 93 N.E./1, 2, 3, 4 S.E./3, 4, 94 N.E./2, 4 S.E./2, 3, 110 N.W./1, 3 S.W./4, 2		1=4	1=2	17	17	...	...	...	...	...	...
Cadastral maps, heading for		...	Scale	2	2	...	...	...	...	...	...
Map of Berar		8=1	12=1	1	2	...	...	...	...	...	...
Register of Expenditure and Receipts of Printing and Miscellaneous Stores		...	...	...	...	...	...	1	1	100	100
A. B. C. Maps, 6		...	...	...	...	...	...	...	2	12	18
Carte de l' Indo-Chine Orientale		...	...	...	...	...	...	1	1	150	150
Telegraph Map of India		...	...	...	...	...	...	...	6	300	300
Bhootia Teapot		...	...	...	...	...	...	1	1	50	50
Form showing Zamindars' and Patwaris' receipts		...	½ scale	1	1	...	1	1	1	1,750	14,000
Scale of contours		...	Scale	1	1	...	1	1	...	...	...
Cadastral work, Register of		...	...	...	...	...	...	1	1	200	200
Burma Survey—											
Sheet 93, Specimen Map of		...	...	...	...	...	...	...	1	100	100
„ 93 S. W. do.		...	...	...	...	...	...	1	1	100	100
Various grains		...	...	...	...	...	...	...	...	...	...

OFFICE, CALCUTTA.

1st October 1885 and 30th September 1886—continued.

Silver and other Printing.			Heliogravure & Electrotyping.					Photo-collotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo-Blocks.	Electrotypes.	Photocollotype Plates.	Photocallotype Prints.	R a. p.	
...	...	...	...	...	...	...	...	...	...	241 2 3	
...	...	...	...	...	...	...	...	...	...	865 13 1	
...	...	...	...	...	...	...	...	...	...	151 15 10	
...	...	...	...	...	...	...	...	...	...	71 12 7	Reprint.
...	...	...	...	...	...	...	...	...	...	19 11 0	
...	12	...	...	...	...	...	...	...	...	43 2 0	
...	...	...	...	...	...	...	...	...	...	14 3 6	
...	...	...	...	...	...	...	...	...	...	17 3 3	
...	...	...	...	...	...	...	...	...	...	22 2 0	
...	...	...	...	...	...	...	...	...	...	127 2 0	
...	...	...	...	...	...	...	...	...	...	25 0 0	
...	...	...	...	...	...	...	...	...	...	18 12 0	
3	...	...	...	...	...	...	...	...	...	31 4 0	
...	...	...	...	...	...	...	...	...	...	41 6 6	
4	...	...	...	...	...	...	...	...	...	9 6 0	
16	32	...	...	...	...	...	...	...	...	111 11 0	
2	...	...	...	...	...	...	...	...	...	1 14 0	
...	...	...	...	...	...	...	...	...	...	91 4 0	
...	...	...	...	...	...	...	...	...	...	286 9 5	
1	...	...	...	...	...	...	...	...	...	15 10 0	
...	...	...	...	...	...	...	...	...	...	80 8 3	
...	...	...	...	...	...	...	...	...	...	12 3 0	
1	...	...	...	...	...	...	...	...	...	6 11 6	
...	...	...	...	...	...	...	...	...	...	103 14 0	
...	...	...	...	...	...	...	...	...	...	111 4 1	
...	...	...	...	...	...	...	...	...	...	186 2 0	
...	...	...	...	...	...	...	...	...	...	16 8 0	
...	...	...	...	...	...	...	...	...	...	6 9 0	
8	...	...	...	...	...	...	...	...	...	16 3 0	
8	...	...	...	...	...	...	...	...	...	16 3 0	
...	...	...	...	...	...	...	...	...	...	103 7 5	
...	...	...	...	...	...	...	...	...	...	2 1 1	Reprint.
51	...	...	...	...	...	...	...	...	...	285 10 0	
...	...	...	...	...	...	2	...	...	...	40 10 0	
2	...	...	...	...	...	...	...	...	...	19 13 0	
...	...	...	...	...	...	...	...	...	...	14 7 3	
...	...	...	...	...	...	...	...	...	...	7 10 11	Reprint.
...	...	...	...	...	...	...	...	...	...	40 12 6	
...	...	...	...	...	...	...	...	...	...	72 2 8	
...	...	...	...	...	...	...	...	1	50	24 14 4	Reprint. Two good Collotype Transfers taken for experiment.
...	...	...	...	...	...	...	...	...	...	350 8 6	
...	...	...	...	...	...	...	...	...	...	10 12 9	
...	...	...	...	...	...	...	...	...	...	28 5 0	
...	...	...	...	...	...	...	...	...	...	119 11 3	
...	...	...	...	...	...	...	...	...	...	29 11 3	
...	...	...	...	...	...	...	...	1	...	15 0 0	Experimental Plates.

Statement of Departmental Work done between

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Number of Sheets or Subjects.	Negatives. Number of Negatives (Direct).	Negatives. Number of Negatives reversed.	Negatives. Transparencies.	Photozincographic Printing. Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
Miscellaneous Maps and Plans—*contd.*		M. I.	M. I.									
Carved sandal-wood Book-stand ends, Attaba and Chilumchee		...	...	2	...	2	2	...	...	...	...	...
Ordnance Survey of Ireland—Sheets 105, 151 and 191		...	...	...	...	...	3	...	...	...	...	...
Stone-carving, Plate of		...	...	...	...	1	...	...	...	...	...	...
Specimen Map (Cadastral)		...	...	...	...	...	...	...	...	1	309	1,850
Special Map		...	Scale	1	1	...	...	1	...	...	...	...
Postal Map of Bengal		...	...	...	...	...	...	...	...	12	60	60
Northern Burma and Regions adjacent		...	...	...	...	...	...	...	...	1	50	50
Sketch Map of the Country round Mandalay		...	...	...	...	...	...	...	...	1	50	50
India: Physical Configuration of India, shewing Cultivated and Irrigated area; Table to illustrate the Trade of India with the world.		...	...	...	...	...	...	...	...	3	15	30
Pishin Valley, plane-table of, by Captain Gore, R.E.		...	...	...	...	...	...	6	...	2	200	200
Metric Tables		...	...	...	...	...	...	4	1	...	...	...
Reconnoissance Map of Burma—Sheets 23 N. W. and S.W.		4=1	4=1	2	6	...	...	6	...	...	...	...
Kathiawar—Sheets 32, 43, 45, 52 and 53		...	...	...	...	...	...	...	...	...	...	...
Mirzapur—Sheets 186 N.E., N.W., S.E. and S.W.; 187 N.E.; 201 S.E.; 202 N.E. and N.W.		...	...	...	...	...	...	...	...	...	...	...
Colonel Tanner's Sketches		...	...	...	...	...	...	...	...	...	...	...
Jewellery and Textile Fabrics		...	...	...	...	...	...	...	...	...	...	...
Map of Agra and surrounding Country		...	...	...	...	...	...	...	...	...	...	...
Photographs of Native Musical Instruments		...	...	...	...	...	...	...	...	...	...	...
Photographs of Ancient Cuttack Sculptures		...	...	...	...	...	...	...	...	...	...	...
Views of the Archæological Survey		...	...	...	...	...	...	...	...	...	...	...
Travancore Jewellery		...	...	...	...	...	...	...	...	...	...	...
Burmese Do.		...	...	...	...	...	...	...	...	...	...	...
Mooltan Pottery		...	...	...	...	...	1	...	...	...	...	...
Darjeeling, Map of		...	...	...	...	...	1	...	...	...	...	...
Indian Atlas—Quarter Sheet 77 S. E. (Original and Duplicate)		...	...	2	...	...	...	...	...	...	...	...
Ditto 28 S. W. (Original and Duplicate)		...	...	2	...	...	...	...	...	...	...	...
Ditto 28 S. E. (Ditto)		...	...	2	...	...	...	...	...	...	...	...
Ditto 39 N. W. (½ portion.)		...	...	1	1	...	1	...	...	...	...	...
Ditto 6 S. E. (portion)		...	...	1	1	...	...	...	...	...	...	...
Ditto 61 S. E.		...	...	1	...	...	...	...	...	...	...	...
Ditto 76 S. W.		...	...	1	...	...	...	...	...	...	...	...
Ditto 39 N. W.		...	...	1	...	...	...	...	...	...	...	...
Ditto 15 N. E.		...	...	1	1	...	...	...	...	...	...	...
Ditto 6 S. E.		...	...	1	1	...	...	...	...	...	...	...
Ditto 38 S. W.		...	...	1	1	...	...	...	...	...	...	...
Map of India, Sheet No. 1 (Original and Duplicate)		32—1	32—1	2	...	...	...	...	...	...	...	...
Ditto Sheet No. 2		32—1	...	1	...	...	...	...	...	...	...	...
View of Snows		...	...	...	...	...	...	...	...	...	...	...
Viceroy's Crest		...	...	...	...	...	...	...	...	...	...	...
Making Tracing Prints		...	...	...	...	...	...	...	...	...	...	...
Total		...	...	159	183	3	8	135	53	84	8,831	23,560
Abstract of Departmental Work.												
General Maps		...	...	...	18	53	...	55	17	59	5,695	5,495
Provincial Maps		...	...	...	3	4	...	4	2	1	270	270
Divisional Maps		...	...	...	...	...	...	...	...	4	200	200
District Maps		...	...	...	58	110	...	105	32	29	12,610	43,150
Plans of Cities and Cantonments		...	...	...	57	154	...	156	53	26	2,320	2,320
Atlas Sheets		...	...	...	2	8	...	12	3	3	103	103
Standard Sheets		...	...	...	538	1,329	...	1,315	410	359	52,676	59,626
Index Maps		...	...	...	55	56	...	62	30	44	10,891	15,420
Technical Charts		...	...	...	2	4	...	4	2	3	75	75
Miscellaneous Maps and Plans		...	...	...	159	183	11	135	53	84	8,831	23,560
Transfers and Proofs		...	...	...	...	...	...	...	...	...	2,690	...
Total		...	...	...	892	1,901	11	1,848	602	612	96,361	150,219

OFFICE, CALCUTTA.

1st October 1885 and 30th September 1886—continued.

Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.		
										₹ a. p.	
...	...	...	...	...	...	...	...	...	...	11 8 2	
...	...	...	...	...	...	...	...	7	795	334 3 7	
...	...	...	...	...	...	...	...	1	...	...	
...	...	...	...	...	...	...	...	...	...	84 14 5	
...	...	...	...	...	...	...	...	...	...	9 9 7	
...	...	...	...	...	...	...	...	...	...	35 4 0	Reprint.
...	...	...	...	...	...	...	...	...	...	11 4 10	
...	...	...	...	...	...	...	...	...	...	15 12 10	Ditto.
...	...	...	...	...	...	...	...	...	...	6 1 10	Ditto.
...	...	...	...	...	...	...	...	...	...	83 15 7	From old negative.
...	...	...	...	...	...	...	...	...	...	27 9 0	Ditto.
...	...	...	...	...	...	...	...	...	...	84 0 0	
...	75	...	...	...	...	...	...	...	...	9 1 10	
...	28	...	...	...	...	...	...	...	...	3 2 5	
12	...	...	...	...	...	...	...	...	...	17 6 5	
10	...	...	...	...	...	...	...	...	...	13 3 2	
2	...	...	...	...	...	...	...	...	...	1 12 9	
2	...	...	...	...	...	...	...	...	...	4 8 0	
7	...	...	...	...	...	...	...	...	...	21 9 7	
25	...	...	...	...	...	...	...	...	...	19 3 2	
...	...	2	...	1	...	...	...	...	...	100 0 0	
...	...	2	...	1	...	...	...	...	...	100 0 0	
...	...	6	...	1	...	...	...	...	...	100 0 0	
...	...	1	...	1	...	...	...	...	...	100 0 0	
...	...	...	...	...	...	...	2	...	...	303 12 0	
...	...	...	...	...	...	...	2	...	...	303 12 0	
...	...	...	...	...	...	...	2	...	...	303 12 0	
...	...	...	...	1	...	...	...	...	...	107 8 0	
...	...	2	...	1	...	...	...	...	...	50 0 0	
...	...	...	...	...	...	...	1	...	...	151 14 0	
...	...	...	...	...	...	...	1	...	...	151 14 0	
...	...	...	...	...	...	...	1	...	...	151 14 0	
...	...	3	1	...	...	...	...	...	...	550 0 0	
...	...	17	1	...	...	...	...	...	...	550 0 0	
...	...	3	...	1	...	...	...	...	...	467 0 0	
...	...	...	...	...	...	...	2	...	...	675 0 0	
...	...	...	...	...	...	...	1	...	...	337 8 0	
...	...	3	1	...	...	...	...	...	...	100 0 0	
...	...	...	...	...	...	...	1	...	...	56 14 0	
...	...	...	...	...	...	...	...	...	...	78 9 6	
154	147	39	3	7	...	2	13	21	845	9,668 3 6	
		Pigment Prints.									
...	...	...	...	...	...	...	...	...	...	2,204 3 3	
...	...	...	...	...	...	...	...	...	...	86 0 4	
...	...	...	...	...	...	...	...	...	...	45 7 9	
...	...	...	...	...	...	...	...	...	...	2,924 9 6	
...	...	...	...	...	...	...	...	...	...	2,652 15 9	
...	...	...	...	...	...	...	...	...	...	160 7 4	
16	5	...	...	...	...	...	...	...	...	32,871 2 6	
...	...	...	...	...	...	...	...	...	...	1,788 11 6	
...	...	...	...	...	...	...	...	...	...	100 15 6	
154	147	39	3	7	...	2	13	21	845	9,668 3 6	
...	...	...	...	...	...	...	...	...	...	.....	
170	152	39	3	7	...	2	13	21	845	52,502 12 11	

PHOTOGRAPHIC

Statement of Work done between 1st

Specification of Plate or Print	Progress made.	Scale of Map.		Number of Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Number of Negatives (Direct.)	Number of Negatives reversed and transparencies.	Number of Photo-transfer Prints.	Number of Zinc Plates transferred.	Number of Zinc Plates printed.	Number of Pulls.	Number of Copies.
Cadastral Maps.											
North-Western Provinces—											
Photozincographs		...	1,692	1,692	...	....	1,685	1,750	1,771	29,826	29,826
Zincographs		...	987	...	...	...	...	987	1,003	16,238	16,238
Total		..	2,679	1,692	...	...	1,685	2,737	2,774	46,064	46,064
Burma—											
Photozincographs		...	1,288	1,288	...	...	1,398	1,237	1,237	42,432	42,432
Zincographs		...	558	...	...	...	...	558	558	19,132	19,132
Total		...	1,846	1,288	...	...	1,398	1,795	1,795	61,564	61,564
Bengal—											
Photozincographs		...	...	...	...	...	...	34	34	1,496	1,496
Zincographs		...	...	39	...	...	...	39	39	1,716	1,716
Total		...	...	39	...	...	...	73	73	3,212	3,212
Assam—											
Photozincographs		...	...	407	407	...	409	408	408	21,624	21,624
Zincographs		...	...	232	...	...	...	232	232	12,296	12,296
Total		...	...	639	407	...	409	640	640	33,920	33,920
Transfers and Proofs		...	...	...	...	...	...	...	...	10,138	...
GRAND TOTAL		...	...	5,203	3,387	...	3,492	5,245	5,282	154,898	144,760
General Abstract of Work.											
Departmental Maps and Plans		...	...	892	1,901	11	1,848	602	612	96,361	150,219
Cadastral Maps		...	...	5,203	3,387	...	3,492	5,245	5,282	154,898	144,760
Extra Departmental Maps and Plans		...	...	626	700	59	472	208	211	55,440	117,770
Grand Total		...	...	6,721	5,988	70	5,812	6,055	6,105	306,699	412,749

OFFICE, CALCUTTA.

October 1885 and 30th September 1886—concluded.

Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.		Value.	Remarks.
Number of Silver Prints.	Number of Blue Prints.	Number of Miscellaneous Prints.	Heliogravure Plates Photo-electrotyped.	Heliogravure Plates Photo-etched.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.	Photocollotype Plates.	Photocollotype Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	25,254 13 0	
...	...	...	...	...	...	...	...	...	...	10,215 5 0	
...	...	...	...	...	...	...	...	...	...	35,470 2 0	
...	...	...	...	...	...	...	...	...	...	20,158 0 0	
...	...	...	...	...	...	...	...	...	...	5,791 0 0	
...	...	...	...	...	...	...	...	...	...	25,949 0 0	
...	...	...	...	...	...	...	...	...	...	263 8 0	
...	...	...	...	...	...	...	...	...	...	458 4 0	
...	...	...	...	...	...	...	...	...	...	721 12 0	
...	...	...	...	...	...	...	...	...	...	8,272 0 0	
...	...	...	...	...	...	...	...	...	...	3,203 0 0	
...	...	...	...	...	...	...	...	...	...	11,475 0 0	
...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	73,615 14 0	
170	152	39	3	7	...	2	13	21	845	52,502 12 11	
...	...	...	...	...	...	...	...	...	...	73,615 14 0	
5,229	20	48	9	11	...	1	...	22	4,035	27,749 7 0	
5,399	172	87	12	18	...	3	13	43	4,880	153,868 1 11	

PHOTOGRAPHIC OFFICE, CALCUTTA.

Statement showing the Amount and Value of work done for other Departments between 1st October 1885 and 30th September 1886.

Name of Department.	Number of Sheets, Sections, or Subjects.	Negatives. Number of Negatives (Direct).	Negatives. Ditto Reversed.	Negatives. Ditto Transparencies.	Photo-zincographic Printing. Number of Photo-transfer Prints.	Photo-zincographic Printing. Number of Zinc Plates transferred.	Photo-zincographic Printing. Number of Zinc Plates printed.	Photo-zincographic Printing. Number of Pulls.	Photo-zincographic Printing. Number of Copies.	Silver and other Prints. Number of Silver Prints.	Silver and other Prints. Number of Blue Prints.	Silver and other Prints. Number of Miscellaneous Prints.	Heliogravure and Electrotyping. Heliogravure Photo-electrotyped. Plates	Heliogravure and Electrotyping. Heliogravure Photo-etched. Plates	Heliogravure and Electrotyping. Heliogravure Prints.	Heliogravure and Electrotyping. Photo. Blocks.	Heliogravure and Electrotyping. Electrotypes.	Photo-collotype. Photo-collotype Plates.	Photo-collotype. Photo-collotype Prints.	Value.	Remarks.
																				R a. p.	
Archæological Survey of India	12	...	12	12	...	1	...	...	...	1	...	17	4	...	...	...	...	2	...	483 4 0	
Adjutant General in India	...	...	...	...	...	...	2	120	180	...	...	...	...	...	...	...	...	...	...	21 6 0	
Asiatic Society of Bengal	5	2	7	7	2	2	2	1,055	3,540	6	...	...	1	...	...	1	...	17	3,743	728 5 0	
Chief Superintendent of Telegraph Stores	12	5	...	...	5	15	26	10,834	40,034	...	...	...	...	...	...	...	...	...	...	1,719 9 0	
Chief Engineer, Bengal, Public Works Department	15	81		...	81	29	27	2,450	2,450	...	...	...	...	...	...	...	...	...	...	1,576 5 0	
Director General of Telegraphs in India	1	2	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25 0 0	
Do. of Railways	2	5	...	...	5	2	2	1,450	1,450	...	...	...	...	...	...	...	...	...	...	201 8 0	
Director of Garrison Instruction in India	3	3	...	...	3	1	1	125	375	...	...	...	...	...	...	...	...	...	...	74 5 0	
Do. of Geological Survey of India	104	...	...	...	...	...	...	...	...	313	...	...	...	...	...	...	...	...	...	187 13 0	
Government of India, R. and A. Department	70	72	2	15	5	5	2	1,000	2,000	797	...	27	4	10	...	...	...	2	...	3,132 6 0	
Do. do. Military Department	7	10	...	...	10	8	10	2,645	6,825	...	...	...	...	...	...	...	...	...	...	483 1 0	
Do. do. Foreign Department	81	100	...	...	32	7	7	518	652	2,844	...	...	...	...	...	...	...	...	...	4,845 15 0	
Do. do. Public Works Department	46	95	...	...	94	39	34	3,490	6,415	100	...	...	...	...	...	...	...	...	...	2,359 4 0	
Do. of North-West Provinces and Oudh	1	10	...	...	10	5	5	750	750	...	...	...	...	...	...	...	...	...	...	257 14 0	
Do. do. do. Public Works Department	18	18	...	...	18	2	2	450	1,265	...	...	...	...	...	...	...	...	...	...	689 5 0	
Do. of Punjab, Public Works Department	15	33	...	...	33	15	4	200	200	...	...	...	...	...	...	...	...	...	...	550 14 0	
Gorakhpur Municipality	5	20	...	...	...	...	...	...	...	...	20	...	...	...	...	...	...	...	...	166 3 0	
Inspector-General of Military Works	37	52	...	...	47	16	18	11,100	28,350	...	...	...	...	...	...	...	...	...	...	2,782 9 0	
Locomotive Superintendent, Indus Valley State Railway	1	1	...	...	1	3	3	60	300	...	...	...	...	...	...	...	...	...	...	61 4 0	
Master of the Mint, Calcutta	16	14	...	...	...	...	...	...	...	269	...	...	...	...	...	...	...	...	...	236 11 0	
Manager, Eastern Bengal State Railway	2	2	...	...	2	2	2	1,030	2,030	...	...	...	...	...	...	...	...	...	...	115 7 0	
Do. Rajputana-Malwa Railway	...	...	...	...	...	1	1	50	100	...	...	...	...	...	...	...	...	...	...	50 0 0	
Do. Bombay, Baroda, and Central India Railway	...	...	...	...	...	1	1	100	100	...	...	...	...	...	...	...	...	...	...	17 13 0	
Meteorological Reporter, Government of India	13	16	...	...	16	7	8	3,135	6,135	...	...	...	...	...	...	...	...	...	...	976 12 0	
Postmaster General, Bengal	8	17	...	...	17	8	8	2,472	1,648	...	...	...	...	...	...	...	...	...	...	1,062 2 0	
Port Commissioners, Calcutta	2	2	...	...	2	2	1	110	110	...	...	...	...	...	...	...	...	...	...	52 15 0	
Port Officer, Calcutta	2	6	...	...	6	2	3	230	230	...	...	...	...	...	...	...	...	...	...	131 8 0	
Quarter Master General in India	17	52	...	...	50	20	24	9,955	9,630	...	...	...	...	...	...	...	...	...	...	2,537 5 0	
Sanitary Commissioner, Government of India	6	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13 13 0	
Do. do. Government of Assam	...	...	...	...	...	...	1	250	250	...	...	...	...	...	...	...	...	...	...	41 6 0	
Secretary to the Board of Revenue, North-West Provinces	4	8	...	...	8	4	4	800	800	...	...	...	...	...	...	...	...	...	...	360 3 0	
Do. to the Chief Commissioner, Central Provinces	1	1	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	12 0 0	
Do. do. Assam	...	...	...	...	...	...	1	250	250	...	...	...	...	...	...	...	...	...	...	50 11 0	
Do. to the Bengal Executive Committee, Indo-Colonial Exhibition	54	54	...	...	1	1	1	30	60	731	...	...	...	...	...	...	...	...	...	961 14 0	
Superintendent, Government Printing, India	12	15	...	...	15	8	10	736	1,591	...	...	...	...	...	...	...	...	...	...	397 2 0	
Do. Carriage and Wagon Dept., East Indian Railway	1	1	...	...	1	1	1	25	50	...	...	...	...	...	...	...	...	...	...	23 12 0	
Lieutenant A. C. Yate	...	...	...	...	...	...	...	...	...	68	...	...	...	...	...	...	...	...	...	172 9 0	
Major H. Cooper, A.-D.-C.	48	...	...	...	...	...	...	...	...	100	...	...	...	...	...	...	...	...	...	59 2 0	
Messrs. Newman & Co.	1	1	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	23 12 0	
,, Ralli Brothers	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12 0 0	
"The Indian Daily News"	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	24	12 0 0	
Dr. G. King (Botanical Gardens)	2	...	2	1	...	...	...	...	...	...	...	4	...	1	...	...	...	...	...	150 0 0	
Dr. V. Richards	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	268	22 8 0	
	626	700	24	35	472	208	211	55,440	1,17,770	5,229	20	48	9	11	...	1	...	22	4,035	27,749 7 0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Extract from the Report of LIEUTENANT-COLONEL J. WATERHOUSE, S.C., *Assistant Surveyor General, in charge Lithographic Office,—Season 1885-86.*

The number of lithographed maps, plans, drawings, &c., taken in hand or printed during the year amounts to 677, of which 190 were for the Survey Department and 487 for other Departments. The total number of impressions or pulls in the Lithographic-printing Section was 424,872, yielding 356,877 complete copies, of which 201,912 were departmental and 154,965 extra-departmental. Although the number of subjects received and of complete copies printed off are somewhat less than last year, the actual printing work done, as measured by the number of press pulls, was much larger and shows an increase of 92,654 over last year. This increase is due to increased demands for forms.

In the Type-printing Section the work has again increased—5,566 pages or items were set up, and the total number of pulls amounts to 928,114; the out-turn last year being 760,670 pulls from 5,687 items.

The hand-power lithographic machine and steam type-printing machine have been steadily employed during the year and have been found to be of the greatest use in enabling the Office to meet the expanding demands for departmental forms and for expediting the supply of urgent work.

I have been anxious to introduce the working of zinc plates with the lithographic machine, and, while in England on privilege leave in 1885, I purchased some of the lithographic plates for trial, as reported in the Photographic Office Report for last year. A trial was made of these plates during my absence this year with promising results, but the difficulty is to make corrections on the plates without having the proper solution for preparing them. I lately saw the manufacturers, Messrs. Layton and Company in London, and obtained from them the latest instructions for working the plates. I also ascertained that they would be prepared to grant a license to enable us to prepare the plates ourselves on reasonable terms, though definite rates have as yet not been fixed. These plates are so thin and light and so easily stowed away that they should offer many advantages. In any case, thin zinc plates might be used in the machine and printed in the ordinary way. I hope to make further trials in this direction immediately.

The expenditure of the Office during the year under report has been R65,824-6-2 and the value of the work performed R63,236-7-2, showing a balance of R2,587-15-0 against the Office. In making out the return of expenditure, the system obtaining in the Photographic Office has been followed, *i.e.*, the expenditure includes the cost of all materials and plant received during the year, and not, as in last year's return, merely the cost of materials actually expended. A system of book-debit account with other departments, similar to that obtaining in the Mathematical Instrument Department and other Government Factories, came into force on the 1st April, and revised cost-rates for work done were introduced at the same time, so that six months of the year, from October to March, were under the old system of accounts, and the other six under the new. The difference between the rates under the two systems is not very great, as both were based upon the principle of approximating as nearly as possible receipts and expenditure. Under the new system a percentage of 20 per cent. in addition is charged to cover cost of wear and tear, increases to stock and plant, and other working expenditure not specially accounted for. Even with this addition the receipts and expenditure should nearly balance, and if they do not, the rates will require readjustment from time to time. Had the 20 per cent. allowance been credited for the work done all through the year, instead of only for the last six months, the balance against the Office would have been much less.

Munshi Mahomed Azim, Examiner, retired on superannuation pension on the 1st May 1886. He had served in the Department for upwards of 34 years, with great credit. He was an excellent draughtsman and compiler and a very useful man in the office.

LIBRARY OF THE BOMBAY BRANCH OF THE ROYAL ASIATIC SOCIETY.

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement of Departmental Work done between 1st October 1885 and 30th September 1886.

Specification of Stone or Print.	Lithographic Printing.							Type Printing.				Value.	Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Number of sheets or subjects.	Number of stones.	Number of colored copies.	Number of uncolored copies.	Number of pages or items.	Number of pulls to each item.	Total number of pulls.	Number of copies.		
		In. Ms.										R a. p.	
General Maps.													
Preliminary Canal Map of India, in 6 sheets, with hills.	Re-transfer made with corrections and color stone prepared.	1 = 32	Dl. elephant.	6	12	...	...	...	...	...	...	259 9 0	Not yet printed.
External Trade Routes of India.	Additions and corrections made.	1 = 80	Special .	1	1	...	112	...	...	112	112	197 15 0	
India, showing Density of Population.	Additions and corrections made and color stones prepared.	1 = 80	Ditto .	1	3	...	...	...	...	...	...	224 6 0	Not yet printed.
Drawn previously but printed during the present year.													
Contour Map of India, in 6 sheets, Nos. 1 to 6.	Corrections made.	1 = 32	Dl. elephant.	6	6	...	200	...	...	1,200	200	967 12 0	
India, showing principal Religions.	Ditto	1 = 80	Special .	1	7	112	...	...	...	784	112	351 2 0	
Reprints.													
Eastern Bengal, Assam, Burma and parts of China and Siam, in 4 sheets.	Corrections and Additions made.	1 = 32	Imperial .	1	8	...	200	...	...	1,600	200	216 3 0	
Lecture Map of India, in 6 sheets, Nos. 1 to 6.	Ditto .	1 = 32	Dl. elephant.	6	6	...	400	...	...	2,400	400	496 5 0	
India, showing Provincial and District boundaries, in 2 sheets.	Corrections made.	1 = 64	Ditto .	2	2	...	250	...	...	500	250	175 2 0	
India, showing the progress of Imperial Survey to 1st October 1885, to accompany Annual Report.	Corrections made and color stones prepared.	1 = 128	Imperial .	1	4	500	25	...	...	2,025	525	206 5 0	
Southern Afghanistan and part of Baluchistan, in 4 sheets, with hills.	...	1 = 4	Dl. Imperial.	4	8	..	75	...	...	600	75	99 11 0	
Provincial Maps.													
Transferred previously from engraved sheets but printed during the present year.													
Skeleton Map of Punjab and Surrounding Countries.	...	1 = 32	Dl. elephant.	1	1	...	75	...	...	75	75	25 10 0	
Drawn previously but printed during the present year.													
Nizam's Dominions, including the Assigned Districts of Berar, in 2 sheets.	Corrections made.	1 = 16	Dl. elephant.	2	2	...	200	...	...	100	100	221 9 0	
Reprints.													
Central Provinces . .	Corrections made.	1 = 80	½ Sheet foolscap.	1	1	...	500	...	...	500	500	87 13 0	
Provinces of Bengal, Behar, Orissa and Chota Nagpore.	Ditto .	1 = 32	Dl. elephant.	1	1	...	200	...	...	200	200	101 8 0	
Ditto ditto, in 4 sheets.	...	1 = 16	Imperial .	4	8	...	100	...	...	800	100	86 13 0	
Punjab	Corrections made.	1 = 80	½ Sheet foolscap.	1	1	...	300	...	...	300	300	26 1 0	
District Maps.													
Transferred from Copperplate.													
Nuddeah	Additions and corrections made.	1 = 4	Atlas . .	1	1	...	...	...	...	...	...	109 3 0	
24-Pergunnahs . . .	Ditto. .	1 = 4	Ditto . .	1	1	...	...	...	...	...	...	159 0 0	Not yet printed.
Julpaiguri . . .	Ditto .	1 = 4	Ditto . .	1	1	...	...	...	...	...	...	126 0 0	
Jessore	Ditto .	1 = 4	Ditto . .	1	1	...	...	...	...	...	...	84 0 0	
Khoolna	Ditto .	1 = 4	Ditto . .	1	1	...	...	...	...	...	...	63 0 0	
Transferred previously from engraved sheets but printed during the present year.													
Shahabad	Further corrections made.	1 = 4	Antiquarian	1	1	...	100	...	...	100	100	94 12 0	
Dacca	Ditto .	1 = 4	Atlas . .	1	1	...	100	...	...	100	100	79 12 4	
Carried over .	...	...	...	45	77	612	2,737	...	...	11,305	3,349	4,180 1 4	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement of Departmental Work, &c.—continued.

Specification of Stone or Print.	Lithographic Printing.							Type Printing.				Value.	Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Number of sheets or subjects.	Number of stones.	Number of colored copies.	Number of uncolored copies.	Number of pages or items.	Number of pulls to each item.	Total number of pulls.	Number of copies.		
		In. Mls.										R. a. p.	
Brought forward	...	...	...	46	77	612	2,737	...	...	11,396	3,349	4,180 1 4	
Reprints.													
Rungpore	Corrections made.	1 = 4	Atlas	1	1	...	150	...	...	150	150	71 14 0	
Sylhet	Ditto	1 = 4	Dl. elephant.	1	1	...	200	...	...	200	200	33 7 0	
Plans of Cantonments and Cities.													
Reprints.													
Calcutta, in 2 sheets	...	6 = 1	Dl. elephant.	2	4	100	...	...	...	400	100	59 0 0	
Calcutta	...	3 = 1	Super-royal.	1	1	...	200	...	...	200	200	10 5 0	
Atlas Sheets.													
Drawn during the year.													
Indian Atlas, Quarter sheet No. 4 N. E.	Drawn on stone.	1 = 4	¼ Sheet Atlas	1	1	...	...	...	...	...	...	249 9 0	Not yet printed.
Transferred from Copper-plate.													
Quarter Sheets, Nos. 47 S.-W., and 49 S.-W.	Corrections made.	1 = 4	¼ Sheet Atlas	2	2	...	200	...	...	200	200	160 4 2	
Standard Sheets.													
Drawn during the year.													
Oudh Revenue Survey, Sheets No. 103 and No. 156.	Re-drawn on transfer paper.	1 = 1	Double royal	2	2	...	...	...	...	...	...	395 8 0	Not yet printed.
Oudh Revenue Survey, Sheet No. 235.	Drawn on transfer paper.	1 = 1	Ditto	1	2	...	...	...	...	...	...	397 12 0	
District Mymensingh Sheets Nos. 315 and 346.	Ditto	1 = 1	Ditto	2	2	...	...	...	...	...	...	795 8 0	
Drawn previously, but printed during the present year.													
Oudh Revenue Survey, Sheets Nos. 135, 150, 163, 164, 176 and 177.	Corrections, &c., made.	1 = 1	Double royal	6	6	...	2,610	...	...	1,610	1,610	1,462 9 10	
District Julpaiguri, Sheets, Nos. 270, 271, 272, 296, 297, 318 and 337.	Ditto	1 = 1	Ditto	7	7	...	1,400	...	...	1,400	1,400	694 7 0	
District Montgomery, Sheet No. 174.	Ditto	1 = 1	Ditto	1	1	...	200	...	...	200	200	124 6 0	
Index Maps.													
Reprints.													
Index Maps, Nos. 1 and 8, Topographical Parties, on the scale of 1 inch=1 mile to accompany Annual Report.	Corrections made and color stones prepared.	...	Foolscap	2	5	940	200	...	...	2,550	1,140	109 9 4	
Index to the Indian Atlas, showing the state of the engraving and materials for engraving to 1st October 1885, to accompany Annual Report.	Ditto	1 = 256	Ditto	1	2	670	100	...	...	1,440	770	96 6 8	
Index to the Indian Atlas, showing the Sheets that have been published to 1st October 1885, to accompany Annual Report.	Ditto	1 = 256	Ditto	1	2	890	200	...	...	1,560	1,090	75 5 8	
Index to the Sheets of the Atlas of India, 1885.	Ditto	1 = 128	Imperial	1	2	...	...	...	...	...	...	54 9 0	Not yet printed.
Miscellaneous Maps	...	...	...	37	45	200	12,698	...	...	14,483	12,798	662 5 4	
Departmental Forms	...	...	...	75	75	...	178,905	...	...	230,814	178,905	10,846 13 2	
Total	...	...	...	190	237	3,312	198,600	...	...	266,503	201,912	21,899 6 6	
Circular Orders	...	...	...	...	...	...	...	62	6,900	...	5,550	368 7 0	
Memoranda, &c.	...	...	...	...	...	...	...	449	215,175	...	189,600	1,908 12 0	
Forms, &c., for Survey Department.	...	...	...	...	...	...	...	746	671,044	...	259,551	7,168 4 0	
Transfers for headings, footnotes, references of published maps for Photo. and Litho. Offices.	...	...	...	...	...	...	...	4,309	34,095	...	34,095	2,880 2 0	
14 Rubber Stamps made for Survey Department.	...	...	...	...	...	...	...	...	...	...	...	52 8 0	
Total	...	...	...	...	...	...	...	5,566	928,124	...	488,796	13,573 0 0	
Total Value	...	...	...	...	...	...	...	...	...	...	...	35,432 6 6	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement showing the Amount and Value of work done for other Departments between 1st October 1885 and 30th September 1886.

Name of Department.	Lithographic Printing.				Total number of pulls.	Number of copies.	Value.	Remarks.
	Number of sheets or subjects.	Number of stones.	Number of colored copies.	Number of uncolored copies.			R a. p.	
Archæological Survey of India	38	12	...	25,560	8,070	25,560	1,094 15 7	
	18	8	...	...	...	...	636 0 0	Not yet printed.
Asiatic Society of Bengal	1	1	...	735	735	735	96 0 0	
Adjutant General, India	14	5	60	1,200	720	1,260	350 15 0	
Calcutta Municipality	1	5	305	...	1,525	305	104 3 0	
Central Provinces, Public Works Department	2	2	...	305	610	305	416 11 0	
Consulting Engineer, India	3	3	...	252	252	252	25 13 9	
Commissary General-in-Chief	6	5	...	1,017	917	1,017	98 0 2	
Chief Commissioner, Central Provinces	2	2	...	1,062	1,062	1,062	160 10 0	
Chief Commissioner, British Burma	1	2	355	...	710	355	92 0 0	
Director of Garrison Instruction in India	5	4	1,435	...	2,170	1,435	266 15 0	
Director of Agriculture, Central Provinces	3	3	...	1,660	1,660	1,660	215 10 0	
Director of Agriculture, Bengal	2	1	...	14,000	7,000	14,000	122 13 0	
Geological Survey of India	8	14	1,352	3,885	11,655	5,237	1,023 8 9	
	1	4	...	...	...	...	58 12 0	Not yet printed.
Government of India, Home Department	1	1	...	415	415	415	39 10 0	
Government of India, Revenue and Agricultural Department	48	58	9,752	5,041	31,033	14,793	2,939 2 6	
Government of India, Military Department	21	2	...	605	105	805	157 14 3	
Government of India, Foreign Department	47	45	30	2,831	2,698	2,861	1,171 12 9	
	8	2	...	...	...	...	49 8 0	Not yet printed.
Government of India, Financial Department	24	6	...	3,000	750	3,000	93 8 0	
	1	1	...	...	...	...	9 6 0	Not yet printed.
Government of Bengal	15	10	...	5,066	3,030	5,066	303 13 9	
Government of Bengal, P. W. D.	6	4	...	420	320	420	176 11 0	
Government of the N.-W. Provinces and Oudh, P. W D.	1	2	...	...	...	...	151 15 0	Not yet printed.
Government of Punjab	13	9	230	4,995	4,235	5,225	480 12 0	
	2	4	...	...	...	...	54 9 0	Not yet printed.
Government of Punjab, Public Works Department	1	1	...	2,000	2,000	2,000	212 6 0	
	4	4	...	...	...	...	591 3 0	Not yet printed.
General Superintendent, Horse and Mule Breeding Operations in India	1	3	105	...	315	105	107 13 4	
	1	3	...	...	...	...	221 1 0	Not yet printed.
Meteorological Reporter, India	21	30	4,160	6,047	14,882	10,207	1,653 4 0	
Meteorological Reporter, Bengal	2	2	...	26,400	26,400	26,400	342 10 0	
Medical College	1	1	...	650	650	650	45 4 0	
Miscellaneous Maps, Plans, &c.	7	5	...	680	780	680	98 12 0	
Ordnance Department, India	2	1	...	300	150	300	34 12 0	
Postal Department, India	1	1	...	210	210	210	187 9 0	
Postal Department, North-Western Provinces and Rajputana	4	4	...	268	468	268	334 3 0	
Port Officer and Registrar of Wrecks	2	4	155	155	620	310	176 8 0	
Political Agent, Baghelkhand	1	1	...	200	200	200	67 7 0	
Police Department	10	5	...	550	300	550	181 4 0	
Quarter Master General in India	46	45	125	3,637	4,157	3,762	3,670 5 0	
	16	26	...	...	...	...	4,935 6 0	Not yet printed.
Rajputana-Malwa Railway	1	1	...	...	...	...	14 6 0	
Sanitary Commissioner, India	21	14	2,110	5,300	8,520	7,410	958 6 2	
Sanitary Commissioner, Bengal	1	6	421	...	2,526	421	359 6 0	
Sanitary Commissioner, Assam	1	2	250	...	500	250	60 9 0	
Secretary for Berar to the Resident at Hyderabad	8	8	...	1,805	1,805	1,805	455 14 0	
Settlement Department, Punjab	1	1	...	4,340	4,340	4,340	993 7 0	
Settlement Department, Julpaiguri	1	1	...	200	200	200	58 14 0	
Superintendent, Government Printing, India	5	5	...	1,665	1,665	1,665	97 7 0	
Superintendent of Forest Surveys	1	1	...	415	415	415	468 14 0	
Surgeon General, Her Majesty's Forces	5	2	...	75	30	75	25 8 0	
	1	1	...	...	...	...	6 0 0	Not yet printed.
Stationery Office	5	6	...	2,120	2,120	2,120	195 4 0	
Telegraph Department, India	11	9	...	4,549	4,939	4,549	437 7 5	
	11	11	...	...	...	...	61 12 0	Not yet printed.
Tirhoot State Railway	1	1	...	505	505	505	82 0 0	
Total	487	420	20,845	134,120	158,309	154,965	27,226 7 5	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement showing Expenditure (Dr.) and Value of work done (Cr.) during the Survey year, from 1st October 1885 to 30th September 1886.

Dr.	R	a.	p.	R	a.	p.	Cr.	R	a.	p.	R	a.	p.
Superintendent's salary	5,444	1	6				Standard and other Maps and Plans issued to the Survey of India Department	10,351	4	0			
Assistant Superintendent's salary	2,000	0	0										
Establishment	33,574	14	11				Miscellaneous Maps issued to the Survey of India Department	661	5	4			
Office rent and taxes	3,859	14	0										
Contingencies	1,322	8	7				Departmental Forms	10,846	13	2			
				46,201	7	0					21,859	6	6
Lithographic, drawing and printing materials received from England	764	5	2										
Litho. stones received from England	889	4	9				Miscellaneous Maps and Plans, extra-departmental	27,226	7	5	27,226	7	5
Type printing materials received from England	62	5	2										
Miscellaneous type received from England	400	14	8				Work done in Type Department	13,573	0	0	13,573	0	0
Paper received from England	4,092	12	9										
				6,209	10	6	Paper supplied to Photo. and other Offices of the Survey of India Department	374	2	0			
Paper received from Stationery Office	12,519	1	11										
Miscellaneous articles received from Stationery Office	78	11	10				Old tin and packing cases sent to Mathematical Instrument Office	72	15	0			
				12,597	13	9							
Broken and miscellaneous type received from Mathematical Instrument Office	8	0	0				Sale of waste paper, &c.	130	8	3			
Map typing machine received from Mathematical Instrument Office	72	7	0								577	9	3
Cost of repair of articles at Mathematical Instrument Office	141	13	0										
				222	4	0							
Type received from Superintendent, Government Printing, India	70	8	7										
Type received from Surveyor General's Office	415	11	8										
				70	8	7							
Paper received from Survey of India Offices	504	4	8										
				466	0	4	Balance against the Department				2,587	15	0
Landing and shipping charges incurred by the Marine Department	56	10	0	56	10	0							
TOTAL				65,824	6	2	TOTAL				65,824	6	2

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE A.

Detail of Issues to, and Receipts from, Provinces and Departments during Financial Year 1885-86.

Provinces and Departments.	M. I. O. Receipts.	M. I. O. Issues.	Debits.	Credits.
	Value, ₹	Value, ₹	Value, ₹	Value, ₹
Archæological Survey	...	361	361	...
Assam	3,010	4,854	1,844	...
Bengal, Civil	24,524	18,348	...	6,176
Bengal, Military	4,546	8,468	3,922	...
Berars	125	73	...	52
Bombay, Civil	1,033	453	...	580
Bombay, Military	3,266	578	...	2,688
Bombay, Military (Egyptian Expedition)	...	23	23	...
Burma	9,181	8,839	...	342
Central India	1,451	330	...	1,121
Central Provinces	3,564	3,627	63	...
Colonial Government, Straits Settlements	...	4,740	4,740	...
Forests	...	2,059	2,059	...
Gazetteers and Statistical	...	36	36	...
General Administration, Foreign States	...	14	14	...
Geological Survey and Museums	...	170	170	...
Inland Customs	...	19	19	...
Land Revenue, Ajmir Land Settlement	...	97	97	...
Law and Justice, Port Blair	...	76	76	...
Madras, Civil	7,475	11	...	7,464
Madras, Military	190	4,104	3,914	...
Marine	49	1,030	981	...
Meteorological Department	342	1,973	1,631	...
Mint	64	...	...	64
North-Western Provinces and Oudh	145	1,292	1,147	...
Political, Afghan Boundary Commission	270	2,075	1,805	...
Punjab	5,690	18,050	12,360	...
Public Works Department, Military Works	4,378	18,321	13,943	...
Ditto ditto, Rajputana-Malwa State Railway	...	92	92	...
Ditto ditto, Rajputana	458	311	...	147
Ditto ditto, Sind-Pishin State Railway	384	17,301	16,917	...
Ditto ditto, Bhopal State Railway	152	...	...	152
Ditto ditto, Coorg	...	31	31	...
Ditto ditto, N. W. Railway	...	1,838	1,838	...
Ditto ditto, E. I. Railway	...	502	502	...
Ditto ditto, Hyderabad	455	533	78	...
Survey Department	22,868	60,362	37,494	...
Telegraphs	...	184	184	...
TOTAL	93,620	1,81,175	1,06,341	18,786
NETT DEBITS	...	...	87,555	
Cash Sales	...	3,767	3,767	
GRAND TOTAL	93,620	1,84,942	91,322	

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE B.

List of Instruments, &c., purchased during 1885-86.

Names of Instruments, &c.	No.	Value.	
		₹	a.
Barometers, aneroid, large	2	72	0
„ „ small	2	50	0
Chains, measuring, iron, 66 feet	150	1,162	8
Clinometers	2	40	0
Compasses, bow, plain, electrum, spring	7	10	12
„ „ ink, brass, jointed	37	39	0
„ „ „ „ double-jointed, plain	12	18	0
„ „ „ electrum, single-jointed	111	231	0
„ „ „ „ double „	45	144	0
„ „ „ „ spring	30	45	4
„ „ pencils, brass, double-jointed, plain	12	18	0
„ „ „ „ jointed	43	46	0
„ „ „ electrum, single-jointed	119	249	0
„ „ „ „ double „	38	122	0
„ „ „ „ spring	7	10	8
„ „ common, brass, 5″	98	118	0
„ „ „ „ 6″	135	211	8
„ „ with pen and pencil points, brass, 6″	23	230	0
„ „ for pen and pencil points, brass, single and double-jointed	53	272	8
„ „ with pen and pencil points, electrum, 6″	16	192	0
„ „ for pen and pencil points, single-jointed, electrum	32	192	0
„ „ for pen and pencil points, double-jointed, electrum	3	22	8
„ Magnetic, for plane-tables, 2″ and 2½″ needles	45	270	0
„ „ pocket, in brass cases	3	10	8
„ „ „ in electrum cases	2	4	0
„ „ „ in wooden cases	11	11	0
„ prismatic, Hunter's pattern	1	30	0
Curves, French, horn set	39	39	0
„ „ single, wooden and ebonite	222	181	3
„ Railway or Circular, large and small sets	2	70	0
Declinometers	3	10	8
Hydrometers, with brass floats	1	47	8
Hygrometers, Mason's	1	11	0
Lamps, bull's eye	6	28	0
Lenses, reading, 1″	55	53	8
„ „ 3½″	1	2	10
Levels, spirit, in metal cases, 1′ 2″	1	7	8
„ reflecting, Abney's	1	20	0
Machines, map-printing, Ordnance pattern	12	510	0
Opisometers	18	87	0
Pedometers	1	5	0
Pens, double or road	1	3	0
Pins for maps, brass	1,660	51	14
„ „ electrum	800	50	0
Prickers	11	11	0
Protractors, plain, circular, brass, 6″, 8″ and 9″	1	12	0
„ rectangular, ivory, 6″	33	99	8
„ „ wooden, 6″	9	4	8
„ Sandhurst, boxwood	19	76	0
Pins for chains, common pattern	8,500	664	1
Rules, carpenter's, boxwood, 2′ 2-fold, 2′ 4-fold, and 3′ 4-fold	62	62	0
Rules, engineering, steel, 1 foot	6	9	0
„ parallel, bar, ivory	1	0	8
Carried over	12,505	5,938	4

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE B—*contd.*

List of Instruments, &c., purchased during 1885-86—continued.

Names of Instruments.	No.	Value.
		₹ a.
Brought forward	12,505	5,938 4
Rules, parallel, bar, wooden, 12″	3	4 8
„ „ on rollers, brass, 9″	1	9 0
„ „ „ „ 12″	1	12 0
„ „ „ „ 2′ and 2½′	2	64 0
„ „ „ electrum, 12″	1	15 0
„ sight for plane-tables	100	300 0
„ straight edge, steel, 6′	1	10 0
Scales, architects, boxwood, sets	1	10 0
„ „ „ single	45	111 0
„ „ ebonite „	4	8 0
„ diagonal, wooden	3	4 8
„ engine divided, card-board, single	24	20 0
„ Marquois, sets, wooden	8	40 0
„ off-sets, ebonite, single	120	60 0
„ off-sets, single, wooden	268	100 8
„ plotting, sets, wooden	11	71 8
„ „ „ ebonite	2	20 0
„ „ ebonite, single	156	199 0
„ „ single, wooden	266	266 0
„ „ triangular section, single, boxwood	8	24 0
Sectors, ivory	33	82 8
„ wooden	35	35 0
Squares, optical German pattern	301	1,955 0
„ set, ebonite, single	135	100 8
„ „ wooden, set	2	15 0
Staves, levelling, telescopic, Sopmith's and Strange's	5	75 0
Stands for plane-tables	325	2,275 0
T Squares, wooden, of sizes	16	40 0
Tapes, measuring, steel, pocket and others	1	18 0
Telemeters	3	135 0
Thermometers, chemical	14	80 0
„ maximum, common, self-registering	7	22 12
„ minimum, common	6	12 12
„ maximum and minimum on same board	3	75 0
„ spare for Syke's hydrometers	12	18 0
„ grass	1	13 0
Trammel heads for beam compasses	3	22 8
TOTAL	1,4432	12,262 4

Books.

Pickering's Physical Manipulations	1	8 7
Blow-Pipe Analysis, Landaner	1	2 12
Hints to Travellers	19	76 0
Manual of Surveying	6	72 0
Practical Surveying, Kelly's	1	7 0
"Light," Mayer and Barnard	1	1 8
Nautical Almanacs	50	83 10
Tables, Hydrometer (Casella's)	1	3 0
Tables, Logarithmic, Chamber's	26	68 10
TOTAL	106	322 15

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE B—*contd.*

List of Instruments, &c., purchased during 1885-86—continued.

Names of Instruments, &c.	No.	Value.
		R a.
Sundries.		
Bars, lengthening, brass	18	4 8
„ „ electrum	11	4 2
Boxes, of sorts	5	5 0
Typing ink, tins	6	21 0
Wooden casks	1	3 7½
Glasses for pluviometers	27	114 0
Ink legs for compasses, brass	37	13 14
„ „ „ electrum	24	12 0
Spare glass and key for a watch	2	2 8
Hand press, with stand	1	25 0
Numbers for chains, iron, sets	1,250	351 9
Pencil legs for compasses, brass	12	4 8
„ „ „ electrum	12	6 0
Telescopes for 3″ pocket sextants and range-finders	12	87 8
Cases, leather	12	42 0
Umbrellas	4	64 0
Knives, pocket	24	21 0
Glass ink-bottles	32	7 14
Stencil plates	123	92 4
TOTAL	1,613	882 2½
Add total of Instruments	14,432	12,262 4
„ „ of Books	106	322 15
SUM TOTAL	16,151	13,467 5½

TABLE C.

List of Instruments, &c., manufactured in Workshop during 1885-86.

Names of Instruments, &c.	No.	Value.
		R a.
Bars, standard, steel	8	222 0
Boards, drawing, deal, large	31	397 1
„ „ „ small	15	109 12
„ „ teak, large	6	52 8
Chains, measuring, 30 and 33 feet	7	31 8
„ „ 66 feet	395	3,357 8
„ „ 100 „	50	500 0
„ other sizes and sorts	301	1,810 8
Clinometers	6	240 0
„ with hill shading scale and plummets	12	18 0
„ survey pattern	25	620 0
Combs, bigha scale	208	52 0
„ acre-calculating card-board	2,040	510 0
Compasses, magnetic, for plane-tables, 5″ needles	45	564 0
Hold alls	24	321 10
Plane-tables, deal	281	2,573 0
„ „ „ military pattern	39	302 8
Pluviometers, country pattern	38	684 0
„ Simon's pattern	36	522 0
Pins for chains, common pattern	2,000	250 0
Quadrants, Gunners'	3	90 0
Rule, sight, for plane-tables	50	200 0
„ „ brass for military plane tables	28	573 1
Rule, sight, for plane-tables with telescopic attachment and metal	24	408 0
Carried over	5,672	14,409 0

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE C—*contd.*

List of Instruments, &c., manufactured in Workshop during 1885-86—continued.

Names of Instruments, &c.	No.	Value.
		ℛ a.
Brought forward .	5,672	14,409 0
Scales, Bengali, metal	104	104 0
„ diagonal, card-board	4,564	664 14
„ „ metal	1	12 3
„ engine-divided, card-board, single . . .	1,000	125 0
„ off-set, single, ivory and slips	415	181 6
„ plotting, single, ivory	6	8 4
Squares, optical, German pattern	12	160 8
Staves, cross or off-sets	2	10 8
„ for omnimeters	3	70 0
„ levelling, Gravatt's pattern	10	160 0
„ telescopic, Sopmith's and Strange's . .	40	600 0
Stands for heliotropes, 6″, 8″, 9″ and 12″ . . .	4	56 0
„ for plane-tables	30	540 0
„ for theodolites	7	221 8
„ for thermometers	12	96 0
Thermometers, minimum, black bulb	2	36 8
„ maximum and minimum on same board .	6	75 0
Vane, sight for referring lamp	2	40 0
TOTAL .	11,892	17,570 11
Sundries.		
Boxes, of sorts	26	61
Cases, packing	680	2,844 2
Stand for camera lucida apparatus	1	35 0
Camera lucida apparatus	1	40 0
Doolies	16	28 0
Girder-tester	1	51 6
Gauges, writing	41	93 0
Globes, metal, wire	1	5 0
Handles, brass for chains	16	12 0
Levels, spirit, for staves	6	33 0
Numbers for chains, brass, single	83	11 10
Plates, copper for scales	1	30 0
Rods for pickets, wooden	6	21 0
Screw-drivers and levers for theodolites . . .	9	6 12
Stool and benches, teak wood	2	145 2
Type-holders for Gastrell's pattern press . .	1	28 11
Tubes, tin and zinc, in wooded cases, &c. . . .	77	54 8
Ink-rollers, small	11	33 0
Plummets	12	13 8
Brass strap keepers for instrument boxes and leather strap	26	2 8
Screws for plane-tables	2	5 4
Washers, brass	506	10 6
Diaphragms for camera	5	2 0
Set of figures for stamping, with handle complete . .	11	25 0
Stands for thermometers, padded	1	4 8
Bottles, metal	5	51 8
Almirahs, mahogany	1	232 0
Spider lines, box	1	2 0
India-rubber rings	12	1 0
TOTAL . .	1,561	3,883 2
Add total of Instruments . . .	11,892	17,570 11
SUM TOTAL . .	13,453	21,453 13
Brass castings, &c., for material stock . .		1,260 0
GRAND TOTAL . .	...	22,713 13

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE D.

List of principal Instruments repaired in Workshop during 1885-86.

Names of Instruments.	Number.
Actinometers	2
Alt-azimuth	1
Anemometers	10
Anemographs	3
Arithmometers	2
Barometers of sorts	66
Boards, drawing, of sorts	13
Camera of sorts	2
Cases, leather, writing	5
Chains of sorts	73
Chronographs	3
Chronometer	1
Clinometers	7
Compass, azimuth	1
Compass, beam	1
Compass, boat	1
Compass, card	1
Compasses, drawing, of sorts	137
„ magnetic, for plane-tables	27
„ „ pocket	14
„ prismatic of sorts	69
„ proportional	9
„ rectangular for theodolite	4
„ Ship	2
„ Surveying, of sort	33
Curves, of sort	1
Glasses, binocular	12
Heliographs	20
Heliotropes	6
Hydrometers	20
Instruments, drawing, of sorts	60
Lamps, bull's eye	6
„ referring	6
Lenses of sorts	3
Levels of sorts	117
Log, patent	1
Machines, hand-printing	8
„ map-printing	2
„ paper-cutting	1
Microscopes, of sorts	4
Padded, boards	2
Pens, drawing, of sorts	112
Pentagraphs of sorts	2
Perambulators	3
Plane-tables	8
Planimeters	16
Pluviometers	4
Polariscope	1
Press, for litho. of sorts	1
Pricker	1
Protractors	5
Quadrants, Gunner's	1
Quintants	2
Range-finders of sorts	41
Refrigerator	1
Rules of sorts	28
„ sight, for plane-tables	8
„ straight edges	3
Carried over	993*

MATHEMATICAL INSTRUMENT OFFICE, CALCUTTA.

TABLE D—*contd.*

List of principal Instruments repaired in Workshop during 1885-86—continued.

Names of Instruments.	Number.
Brought forward	993
Scales of sorts	13
Seismometer cylinder	4
Sextants of sorts	8
Spectroscope	1
Squares, optical	63
Stand for barometer	1
Stand for camera	1
Stands for compasses	64
„ „ heliographs	14
„ „ heliotropes	2
„ „ levels	54
„ „ plane-tables	7
„ „ theodolites	50
„ „ thermometer	1
Staves of sorts	75
T squares of sorts	6
Tapes of sorts	72
Telescopes of sorts	27
Theodolites of sorts	95
Thermometers of sorts	20
Tide-gauge clocks	2
Watches	2
Wind vanes	17
Van Rysselberghe's meteorograph	1
Total of principal Instruments repaired	1,593
Total of all Instruments repaired	2,267

Profit and Loss Account of Workshop for 1885-86.

Debits.	R a.	Credits.	R a.
Workshop Establishment (less proportion debitable to the Store Branch for cleaning and adjusting serviceable Instruments)	33,829 7	By repairs for Public Officers	14,457 9
One-third of Office Establishment	2,255 1	Ditto to Stock	21,377 12
Workshop contingencies as distinguished from materials purchased	1,260 10	By manufactures for Stock :—	
Value of materials :—		"Instruments"	18,582 15
For special work	11,577 7	"Packing Cases"	2,870 14
For general workshop use	456 12	By manufacture for materials	1,260 0
For manufacture of packing cases	1,722 9	Ditto for store	890 7
Paid for repairs	177 0	Work on prepayment	1,472 4
Wear and tear of plant	1,116 0		
Half of rent at R325 per mensem	1,950 0		
Printing and Stationery	207 3		
4 per cent. on value of Tools and Plant, amounting to R61,811	2,472 7		
Workshop profit	3,887 5		
TOTAL	60,911 13	TOTAL	60,911 13

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Extracts from the Narrative Report of MR. W. H. COLE, *M.A., Deputy Superintendent, 3rd grade, in charge of the Computing and Type-printing Sections of the Trigonometrical Branch Office, Dehra Dún,—Season 1885-86.*

The following tabular statements exhibit the money value of the work performed by the Computing Section :—

Statement of Expenditure (Dr.) and Amounts credited (Cr.) on account of the Computing Section during the Survey year 1st October 1885 to 30th September 1886.

DR. CR.

	R	R		R	R
Deputy Superintendent's salary	11,400		Work done for the Survey of India Department as shown in the following table	51,825	51,825
Assistant Superintendent's salary	7,000				
Establishment	33,500				
Contingencies	963	52,863			
Stationery	100	100	Extra Departmental work done	2,150	2,150
Library, books and periodicals	*1,012	1,012			
TOTAL	...	53,975	TOTAL	...	53,975

* Including charges for books, &c., obtained during the two preceding seasons.

Statement of Departmental Work done by the Computing Section between 1st October 1885 to 30th September 1886.

	Class.	Value.
		R
1	Records, Library, inclusive of cost of purchase of books, &c.	2,235
2	Computations	21,510
3	Accounts, Returns, Correspondence	7,968
4	Supply of Data, &c.	8,730
5	Preparation of Press-Copy	9,281
6	Examination of Press Proofs	5,209
7	Ditto Charts, &c.	665
8	Protection of Stations	1,230
9	Miscellaneous	9,286
10	Meteorology and General Science	2,711
	TOTAL	51,825

Statement showing the value of work done for other Departments by the Computing Section between 1st October 1885 and 30th September 1886.

Name of other Department.	Value.
	R
Quartermaster General's Department in India	1,484
Meteorological Department	516
The Officer on special duty, Kashmir Railway Project Survey	150
TOTAL	2,150

The preceding statements afford a fair idea of the cost of the work performed under the various classes; but some explanation of these is necessary, and will now be given.

CLASS 1, RECORDS, LIBRARY.—The records of all the survey operations appertaining to the Trigonometrical Branch, from the time of Colonel Lambton to the present date, find a resting place in this office, where they are carefully stored and periodically inspected. Further, as each fresh instalment is received it is closely examined, indexed, registered, and a detail receipt furnished to the executive officer from whom it comes. During the past season a mass of records of the Káthiáwár Topographical Survey Party was received for deposit, and the examination has occupied a large share of the time of one computer for several weeks.

The custody of the Library, which now contains about four thousand books and pamphlets, chiefly of a scientific character, also comes under this head, as well as the cost of

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

books and periodicals purchased during the year, both for the Library itself and also for several survey parties of the Trigonometrical Branch. In the present instance, owing to the bills for the two preceding years not having been presented till recently, the cost includes three years' purchases.

CLASS 2, COMPUTATIONS.—The duty of this office is stated elsewhere to be the final reduction and publication of the operations of the Trigonometrical Branch. These operations consist of the execution of series of triangulation, in the taking of astronomical observations, in the carrying of lines of spirit levels over the country, &c. Primary reductions are made in the offices of the parties which execute the several works in order to present them complete each in itself; but a great deal then remains to be done before those works can be presented to the public, and it is necessary to fuse into a harmonious whole all the various geodetic operations: to effect this, very intricate calculations are required, and they form the main work of this office. Under this head may be specially mentioned the following:—

(1). The final reduction of the principal triangulation of the *South-West Quadrilateral.* This was commenced last year, and the main reduction was completed during the year under report, leaving for final adjustment only those portions of the principal triangulation which did not enter the circuit equations. That which appertains to two out of five series has been disposed of and greater progress would have been made, but that it was necessary to divert the computers engaged on it to other work of a more urgent character. When this quadrilateral is finished, the whole of the principal triangulation of India west of the meridian 92° will have been finally reduced.

(2). In the *Southern Trigon,* the work done has been chiefly in connection with the reduction of the secondary triangulation, of final terms, including a considerable portion of Colonel Lambton's operations. The principal triangulation, except so far as the heights of the stations are concerned, which await the completion of levelling operations in Southern India, is all reduced and the data nearly ready for the press.

(3). Only two Synoptical Volumes remain to complete the publication of the whole of the details of the *North-East Quadrilateral, viz.*, those of the North-East Longitudinal Series and the Assam Longitudinal Series which also includes the Assam Valley Series. The former cannot be taken in hand yet because the triangulation for fixing snow peaks is not complete. With the latter considerable progress has been made, and there only remains to obtain the values of the distances and azimuths of snow peaks in final terms to complete the data for the volume; this is in hand.

(4). *Observed Latitudes.*—Observations of 1884-85, having been received from Astronomical Party No. 1, were finally reduced in the same manner as all the previous observations, and now those from Colonel Lambton's time to the end of the above-mentioned season are completely reduced, and the preparation of the details for the press is in hand and considerable progress has been made with the copy.

(5). *Electro-Telegraphic Longitudes.*—Assistance was afforded to Astronomical Parties Nos. 1 and 2 in bringing up their calculations for 1885-86. These calculations were performed under the direct superintendence of Lieutenant S. G. Burrard, R.E., and the assistance rendered was equivalent to the services of a pair of computers for a little short of three months.

(6). *Khandesh Topographical Survey.*—In compliance with the directions of the Officiating Surveyor General a pair of computers was placed under the orders of Mr. W. H. Patterson, Officiating Deputy Superintendent, 4th grade, for a little over two months, to aid in bringing up the arrears of this survey.

(7). The new edition of the *Auxiliary Tables to facilitate the calculations of the Survey of India* has been steadily in hand and good progress has been made with it. The necessary calculations have been completed up to the end of Table LIII.

CLASS 3, ACCOUNTS, RETURNS, CORRESPONDENCE.—Under this heading are included Indents, Estimates, Monthly detailed and abstract progress reports, stock returns of ordnance stores, the compilation of the Annual Report and various other items. Assistance has also been rendered in the current work of the Deputy Surveyor General's Office.

CLASS 4, SUPPLY.—Requisitions from 18 officers for data of various kinds have been complied with, some of which involved a good deal of discussion and calculation. In this class is also included the cost of labour in the despatch of maps, charts, books, and forms.

CLASS 5, PREPARATION OF PRESS COPY.—This consists in the writing of the letterpress for the several publications; and also in abstracting and compiling the results of the several calculations in a suitable form for publication. All tabular data when so compiled are carefully compared twice before handing to the printer. The details of the work under this head are as follows:—

Southern Trigon.—The manuscript for the Introductory Chapters of the Volume, which will contain the details of this section of the principal triangulation, has been commenced, and nearly the whole of the numerical and descriptive data have been compiled for the press of which a great portion has been finally compared.

North-West Quadrilateral.—The remaining portion of Professional Volume IVA. (Jodhpore and Eastern Sind Meridional Series) was completed. The volume has now been bound and is in course of issue. The compilation of the corresponding Synoptical Volume is nearly complete.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Observed Latitudes.—The calculations having been completed, the preparation of the details for the press has been taken in hand and a good deal of copy is ready.

Auxiliary Tables to facilitate the Calculations of the Survey of India.—Several tables have been compiled and the explanatory introduction has been re-written for the first 52 tables, with considerable additions.

Spirit-levelled Heights.—Pamphlets Nos. 2 and 3 of Levels in the Bombay Presidency and the Nizam's Dominions, and No. 1, Madras Presidency, were revised and corrected for the press. That for the Bombay Presidency is complete and is being got ready for issue, while the pamphlet for Madras only requires a chart (which will shortly be ready) to complete it also. Other subjects were of lesser importance and need not be detailed here.

CLASS 6, PRESS PROOFS.—The work done under this heading properly relates entirely to the Printing Section, for it consists of the examination and comparison of proofs; and as most of the matter printed is numerical or depends on numerical data, this examination can only be performed by men thoroughly acquainted with all the details of the subject in hand. Ordinary press-readers therefore could not be expected to render the critical examination which such matter requires. The charge for this class, though necessarily included in the cost of the Computing Section, has also to be reckoned in calculating the value of the work turned out by the Printing Section, and it is accordingly distributed over the various works of that section. Should the cost of the two sections be combined this charge (₹5,209) should manifestly be deducted from the total.

CLASS 7, CHARTS.—The careful examination of all charts of triangulation and of spirit-levelled heights before publication, is a matter of very great importance, and this work is also performed by the Computing Section, where the familiarity with the original records renders the detection of mistakes much easier and more certain than if the examination was made by the draftsmen themselves. All the charts, diagrams, &c., prepared during the year by the Drawing Section for the publications of the office were so examined; among them may be especially noted the Reduction Chart of the Eastern Sind Series of the Principal Triangulation for Professional Volume IV A., and the final chart of the Jodhpore Series for the Synoptical Volume, while several of the Degree Sheets of the Assam Longitudinal Series for the Synoptical Volume of that series have received their first comparison.

CLASS 9, MISCELLANEOUS.—In this class is included several duties of the Computing Section which cannot fairly be assigned to any of the other classes.

Early in 1886 Colonel Haig directed that a short base-line should be measured with the Colby compensation bars and microscopes for the purpose of instructing the officers and assistants of the department who were then present at Dehra in the use of the base-line apparatus, as it appeared to him that those who had had experience in such operations were gradually leaving the department without handing on their experience to their successors. He selected a site in the southern portion of the field adjoining the Survey office in which the observatory for the large photo-helio. stands. The ends of the base-line were marked by masonry pillars, surmounted by circular stone caps containing dots on silver plugs let into brass, the dots being flush with the ground level.

The length of the base-line was first chained and so chosen as to be nearly equal to 11 sets of bars and microscopes, when arranged in line for measurement, or 231 yards. The preliminary operations began on the 11th February and continued till the 12th April, partly in order that the work of the office might not be interrupted, and partly in accordance with Colonel Haig's desire that as much opportunity as possible might be afforded to officers visiting Dehra of seeing the process.

The officers who took part in the preliminary operations and the measurement itself were as follows:—

Colonel C. T. Haig, R.E.
Mr. W. H. Cole, M.A.
„ J. Eccles, M.A.
„ C. Wood.
„ A. J. Wilson.
„ G. W. E. Atkinson.
„ J. A. May.*
Mr. H. W. Peychers.
„ W. W. McNair.
„ C. H. McA'Fee.
„ J. Bond.
„ W. J. Cornèlius.
„ F. E. Warde.

Before the conclusion of the measurement Major G. Strahan, R.E., arrived from the field and took the opportunity of inspecting the operations.

None of these, except Mr. Bond, had ever been present at a base-line measurement, and *he* had only taken a minor part. I myself had had a good deal to do with portions of the apparatus, especially when I assisted in the re-determination of the factors of expansion of standard Bar A. I had also assisted General Walker in the preparation of Volume I of the Operations of the Great Trigonometrical Survey of India, the subject of which is the measurement of the base-lines in India, and further the Mergui Base-line had been reduced under my direct superintendence. I therefore possessed a considerable theoretical knowledge of the subject, and with the aid of the article on geodesy by Captain Yolland,

* Died, 26th June 1886.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

R.E., in the course of Mathematics prepared for the use of the Royal Military Academy, I had no difficulty in carrying out Colonel Haig's orders. The Base-line apparatus required a good deal of cleaning and preparation before it was ready for use. This work was principally performed by Mr. Eccles and myself, aided by Mr. Bond. As the standard Bar A is in store at Calcutta, Bar $\frac{1}{B}$ was used for comparison with the compensation bars; this is one of the two 10-foot standards which were constructed for this survey by Messrs. Troughton and Simms in 1864, and its relation to Bar A being known, its use has only entailed a slight extra calculation to reduce the base-line to the same terms as all others.

The work commenced with the comparison of the thermometers against standard No. 4246 at intervals of temperature of about 2°, ranging from 56° to 88° F.

After this the Base-line microscopes were set up on the comparing pillars in the Bar-room and their runs determined against two $\frac{1}{20}$th inch spaces on the standard steel Foot IF by Troughton and Simms. This operation was repeated after the measurement of the Base-line in accordance with the usual custom.

The next operation was the adjustment and testing of the compensation microscopes for "collimation," "verticality" and "parallelism," and then their comparison with their scales. Seven microscopes were employed. The comparison of the microscopes with their scales was also made again after the measurement. The index errors of the levels on the compensation bars were ascertained by means of a dumpy level placed equally distant from the tongues of the bars. This was done once for all.

Bar comparisons with the standard were made before and after the measurement of the Base-line.

The Base-line itself was measured at the rate of one set of six bars with the microscopes per diem: the exact length as determined by the bars was 693·104 feet of standard Bar A.

I may mention that Mr. Eccles has been thoroughly instructed in every process, mathematical and practical. The time of the other officers could not be spared more than to enable them to take an educational share in the different practical operations as they proceeded. I am indebted to Mr. Bond for the assistance he afforded in several practical details, such as the laying out and clearing the line, fixing the terminal points, adjusting the trestles, &c.

The remaining miscellaneous work was principally as follows:—

Two candidates were examined for the Junior Division of the Department. Sixty-six sets of observations for time were taken and reduced, and the rating of chronometers and of the Dehra office turret-clock attended to. A sub-surveyor was instructed in taking and reducing observations for time, latitude, and azimuth. Observations of 22 stars for latitude, made at the Dehra Observatory, were reduced. Several observations for longitude by zenith distances and for azimuth, taken by officers of the department for practice, were reduced for them.

The index errors of certain Meteorological Instruments were determined and many other minor duties were performed.

CLASS 10.—METEOROLOGY AND GENERAL SCIENCE.

Explorations.—The diary of an explorer has been translated into English and revised.

Actinometry.—The comparisons for determining the relations of certain Thermometer tubes to the standard were resumed and completed.

Meteorological Observations.—No change has been made on the procedure of former years. The results of the observations taken at Dehra Dún twice daily throughout the year have been supplied to the Meteorological Reporter to the Government of the North-West Provinces and Oudh; daily weather telegrams were sent from Mussooree to Simla during the five months the office was open at Mussooree, and anemograms for Mussooree for five months and for Dehra for twelve months have been furnished to the Meteorological Reporter to the Government of India. The usual tables of monthly results and of the mean velocity of wind at Dehra are appended. Another twelve months' observations of earth thermometers have been added to the results exhibited in the table at page cxlvi of the Administration Report for 1884-85. The office having now been established in the same locality in Mussooree for twenty-one years, and registers of the rainfall having been kept regularly throughout each season, it has been thought that a table showing the average fall to date, from the 1st June, for the rainy season, would be both of value and interest. This table has accordingly been added to those usually furnished. It should be remarked that the rainfall in Mussooree varies very much with the locality. Much larger falls are registered at lower elevations than at this office, and especially where there are gorges.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

MEAN MONTHLY READINGS OF EARTH THERMOMETERS.

Depth in feet of thermometer bulbs below surface of ground.	Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
		°	°	°	°	°	°	°	°	°	°	°	°
25·6	1881	...	...	...	...	...	73·55	73·90	75·02	76·07	76·09	76·98	*76·71
	1882	75·91	75·13	74·52	74·11	73·97	74·05	74·31	74·95	75·69	76·14	76·39	76·37
	1883	75·85	75·02	74·28	73·89	73·97	73·96	74·32	74·90	75·66	76·16	76·28	76·12
	1884	75·20	74·39	73·90	73·64	73·65	73·95	74·34	76·00	76·87	77·33	†77·27	76·72
	1885	75·83	74·93	74·34	74·00	73·92	74·02	74·25	‡	‡	‡	‡	
	1886	‡	‡	‡	‡	‡	‡	‡	‡	‡	...	...	...
12·8	1881	...	...	...	...	...	74·87	76·47	77·88	78·98	79·26	77·71	74·89
	1882	72·33	70·79	70·47	71·70	73·37	75·23	76·87	78·20	78·98	79·02	77·64	74·89
	1883	72·46	70·36	69·83	70·94	73·00	75·17	76·82	78·20	78·97	78·93	76·93	73·50
	1884	70·95	69·75	70·04	71·47	73·39	75·75	77·42	79·24	79·82	79·34	§77·08	74·52
	1885	72·18	70·37	70·03	71·14	72·86	75·09	77·09	78·98	79·42	79·25	77·93	75·36
	1886	72·49	70·56	70·26	70·95	72·40	74·12	76·18	78·63	79·54	...	...	...
6·4	1881	...	...	...	...	...	80·66	81·01	80·75	81·24	80·33	75·80	70·58
	1882	67·17	66·06	67·75	72·20	76·47	80·01	80·78	81·30	81·32	80·16	75·75	71·03
	1883	67·64	65·10	66·48	71·00	76·72	79·29	80·70	81·42	81·12	79·50	74·50	68·71
	1884	66·03	65·61	67·95	72·36	76·99	80·76	81·46	81·64	81·10	78·85	73·81	69·57
	1885	66·64	64·83	66·73	71·10	74·29	77·59	80·32	80·77	80·85	79·90	76·19	70·97
	1886	66·53	64·72	66·61	69·99	74·87	77·87	80·34	81·54	81·70	...	...	...
3·2	1881	...	...	...	...	..	85·93	83·29	82·03	82·40	79·67	72·20	65·59
	1882	62·57	62·31	67·61	75·49	80·86	84·77	82·71	83·04	82·20	79·21	71·73	66·14
	1883	62·27	60·70	64·83	74·13	81·57	83·44	83·00	83·43	81·74	78·23	69·72	62·50
	1884	61·23	61·90	67·69	75·75	82·32	85·11	84·20	81·94	81·38	76·50	69·32	64·18
	1885	61·38	60·28	65·97	73·52	76·30	82·30	82·68	80·94	81·35	78·73	72·55	65·37
	1886	60·79	60·22	65·33	72·39	78·89	82·14	82·55	82·48	82·37	...	...	...
1·1	1881	...	...	...	...	...	89·16	84·14	82·55	83·19	77·81	67·81	60·72
	1882	58·91	59·41	69·50	78·88	84·99	88·24	83·48	84·08	82·89	77·85	67·96	62·17
	1883	57·98	58·45	65·87	79·55	86·65	87·94	84·55	84·89	82·19	76·70	65·41	57·83
	1884	58·28	59·89	69·56	80·14	88·27	88·57	85·59	82·03	81·64	74·14	65·38	60·10
	1885	57·35	57·75	68·28	77·20	78·63	87·22	84·35	81·16	82·09	77·45	69·03	60·91
	1886	57·13	57·76	66·25	77·19	83·02	86·44	83·78	82·99	83·16	...	...	...
Thermometer in shade.	1881	...	...	...	...	..	87·68	82·54	81·00	82·86	82·72	75·22	71·19
	1882	66·77	66·51	81·36	88·72	91·04	89·11	81·61	82·40	84·62	83·47	75·04	72·36
	1883	64·80	68·72	75·89	91·83	95·54	90·60	83·54	83·85	82·86	82·00	70·95	66·12
	1884	67·36	68·52	81·32	89·51	97·33	89·69	83·86	79·73	80·30	77·30	71·77	67·37
	1885	62·50	65·44	79·35	85·63	84·47	91·97	82·74	79·08	82·41	81·98	75·09	66·31
	1886	63·04	67·49	73·74	88·55	87·82	90·60	82·35	81·75	85·05	...	...	...

* The hole which had gradually filled up about 2½ feet was dug down to the original depth between the 20th and 24th December 1881.

† The hole which had gradually filled up 2 feet since December 1881, was dug down to the original depth between the 9th and 18th November 1884.

‡ Earth fell in from the sides of the hole on the 2nd and 3rd August 1885, and covered the thermometer to the depth of 11 feet. It has been found impossible, as yet, to sink another thermometer to this depth.

§ The hole which had gradually filled up 11 inches since June 1881, was dug down to the original depth on the 17th and 18th November 1884.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Mean Velocity in Miles of the Winds which blew at Dehra Dún during the Twelve Months of 1885-86 for each Hour of the Day.

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	0·97	0·83	0·42	0·32	0·54	1·13	0·70	0·55	0·33	0·10	0·32	0·92
1 „ 2	1·00	0·80	0·23	0·55	0·57	0·84	0·47	0·39	0·40	0·23	0·30	0·73
2 „ 3	0·77	0·53	0·29	0·42	0·25	0·90	0·40	0·55	0·30	0·45	0·13	0·50
3 „ 4	0·58	0·33	0·29	0·45	0·25	0·55	0·47	0·65	0·43	0·32	0·30	0·63
4 „ 5	0·42	0·10	0·13	0·52	0·21	0·45	0·23	0·35	0·40	0·19	0·23	0·37
5 „ 6	0·48	0·10	0·19	0·61	0·29	0·32	0·33	0·42	0·27	0·06	0·08	0·44
6 „ 7	0·29	0·07	0·26	0·48	0·61	0·35	0·27	0·26	0·17	0·29	0·07	0·27
7 „ 8	0·13	0·10	0·03	0·29	0·25	0·32	0·30	0·39	0·23	0·06	0·08	0·65
8 „ 9	0·10	0·03	0·06	0·42	0·43	0·23	0·47	0·65	0·50	0·26	0·30	0·42
9 „ 10	0·42	0·13	0·10	0·68	0·75	0·42	0·90	1·13	0·77	0·32	0·62	0·90
10 „ 11	0·94	0·30	0·29	0·81	1·29	0·74	1·57	1·45	1·23	0·48	0·80	1·31
11 „ 12	1·06	0·67	0·77	1·61	1·29	1·55	2·10	1·39	1·37	0·81	0·85	1·08
12 „ 13	1·48	0·93	0·87	1·58	1·46	1·74	1·90	1·55	1·63	0·74	0·65	1·06
13 „ 14	1·58	0·97	0·90	1·06	2·25	2·77	2·50	2·29	2·03	0·77	0·85	1·13
14 „ 15	1·58	1·07	0·81	1·74	2·32	2·71	2·70	2·52	1·63	0·97	0·81	1·15
15 „ 16	1·03	0·73	0·74	1·26	1·82	2·16	2·30	2·35	2·00	1·00	0·81	1·17
16 „ 17	0·58	0·27	0·48	0·94	1·43	2·29	2·07	1·84	2·07	0·58	0·60	0·87
17 „ 18	0·32	0·13	0·13	0·48	0·89	1·74	1·47	1·58	1·33	0·29	0·48	0·33
18 „ 19	0·94	0·47	0·10	0·29	0·50	0·58	0·30	1·19	0·63	0·32	0·50	0·38
19 „ 20	1·32	1·00	0·13	0·16	0·43	0·68	0·23	0·90	0·60	0·26	0·40	0·79
20 „ 21	1·29	1·13	0·29	0·29	0·36	0·61	0·33	0·55	0·53	0·13	0·13	0·62
21 „ 22	1·94	1·03	0·39	0·55	0·50	0·65	0·67	0·81	0·67	0·29	0·30	0·77
22 „ 23	1·97	1·13	0·65	0·58	0·54	0·90	0·77	0·58	0·50	0·55	0·10	0·94
23 „ 24	1·45	1·07	0·32	0·32	0·50	0·81	0·97	0·55	0·73	0·52	0·17	1·27
Sums	22·64	13·92	8·87	16·41	19·73	25·44	24·42	24·89	20·75	9·99	9·88	18·70
Average	0·94	0·58	0·37	0·68	0·82	1·06	1·02	1·04	0·86	0·42	0·41	0·78

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Monthly Meteorological Results

Year and Month.	Barometer reduced to 32° Fahrenheit.						Hygrometer.			
	At 9-30 A.M.			At 3-30 P.M.			At 9-30 A.M.		At 3-30 P.M.	
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean temperature of dew point.	Monthly mean humidity.	Monthly mean temperature of dew point.	Monthly mean humidity.
1885.										
October	27·797	27·655	27·718	27·667	27·567	27·621	57·7	·621	57·9	·479
November	·937	·711	·827	·827	·629	·736	49·2	·619	50·5	·464
December	·897	·673	·814	·827	·608	·729	46·5	·760	47·2	·556
1886.										
January	28·065	·621	·795	·954	·525	·724	45·6	·786	47·1	·596
February	27·906	·626	·763	·809	·544	·686	44·6	·713	45·1	·467
March	·906	·567	·696	·839	·476	·618	52·8	·659	52·9	·511
April	·701	·484	·603	·604	·389	·518	50·5	·395	48·8	·274
May	·681	·459	·560	·591	·353	·469	60·5	·497	59·1	·411
June	·542	·301	·428	·453	·227	·344	67·5	·579	66·5	·500
July	·505	·311	·400	·431	·249	·331	75·2	·856	76·7	·818
August	·512	·340	·442	·432	·236	·356	74·2	·888	75·4	·813
September	·705	·388	·550	·607	·364	·463	71·6	·812	72·8	·699

The following table gives the average rainfall in inches to date, for the months of June the records kept at the Trigonometrical Branch Office,

Day of the month.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
June	·04	·11	·24	·33	·36	·44	·63	1·21	1·36	1·52	1·68	1·83	1·98	2·18	2·31
July	9·83	10·80	11·55	12·20	13·14	13·71	14·87	15·61	16·14	16·79	17·62	18·25	19·10	20·04	20·95
August	39·09	40·78	41·45	42·27	43·02	44·10	45·51	46·67	47·49	48·45	49·16	49·71	50·38	51·07	52·00
September	64·67	65·45	65·79	66·13	66·73	67·23	67·63	68·04	68·57	69·14	69·75	70·07	70·23	70·38	70·58

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

taken from the Register.

THERMOMETER.								RAIN.		WIND.	CLOUD.	
DRY BULB.					WET BULB.							
Maximum in sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum in wet.	Minimum in wet.	Monthly mean wet.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 9-30 A.M.	At 3-30 P.M.
105·4	46·8	86·6	54·F	71·5	71·5	49·1	61·1	0	·0	N.	0	0
97·4	38·5	27·6	46·3	63·8	68·4	42·1	54·6	0	·0	Calm.	0	1
86·4	33·4	70·3	40·2	56·3	57·9	37·4	50·0	4	3·78	Calm.	2	4
83·0	33·9	68·5	39·6	54·9	57·8	38·1	49·6	7	3·29	Calm.	5	6
93·1	29·8	77·8	35·4	56·8	62·9	34·3	49·2	5	1·69	Calm.	4	4
101·4	41·8	82·9	46·8	65·1	69·4	44·2	56·7	10	2·76	Calm.	4	6
116·5	41·6	97·7	48·6	75·0	71·5	42·6	59·1	1	·03	Calm.	1	2
115·8	53·7	98·2	58·7	79·4	77·9	55·3	66·4	7	3·56	Calm.	2	5
117·2	57·0	102·0	62·9	82·9	79·5	53·7	71·0	10	7·72	Calm.	3	4
110·8	68·9	89·2	71·1	80·2	82·1	69·4	75·6	24	35·47	Calm.	8	8
108·9	65·9	88·0	70·1	78·2	79·5	66·2	74·1	26	28·27	S.	7	7
106·9	61·2	86·8	66·4	77·8	79·7	61·4	71·6	11	8·03	N. W.	3	5

to September, commencing from the 1st June, for the 21 years 1866-86, as obtained from Evelyn Hall, Mussooree. Height above mean sea level 6,880 feet.

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average for the month.
2·38	2·63	2·79	3·00	3·29	3·89	4·09	4·71	4·90	5·76	6·10	6·64	7·20	7·87	8·73	...	8·73
21·79	22·63	24·44	25·46	26·31	27·25	28·53	29·55	30·60	31·71	33·11	34·10	35·15	36·19	37·44	38·21	29·48
52·88	53·83	54·79	55·49	56·17	56·75	57·37	57·91	58·61	59·46	59·94	60·51	61·34	62·07	63·16	64·17	25·96
71·08	71·39	71·91	72·02	72·24	72·36	72·51	72·68	72·85	73·04	73·17	73·34	73·35	73·43	73·58	...	9·41

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

TYPE-PRINTING SECTION.—The usual table showing the work annually performed by this Section during the past five years is given below, the unit (a page of foolscap) being the same throughout. It will be observed that the out-turn of the past year is largely in excess of any previous one.

	1881-82.	1882-83.	1883-84.	1884-85.	1885-86.
Pages composed	1,283	1,381	1,489	1,505	1,340
,, printed	471,616	475,586	362,386	470,970	638,593

An analysis of the pages composed is as follows:—

		Pages.
For Professional Volumes	Longitude Operations	249
	Latitude ,,	14
	Jodhpore and East Sind Meridional Series	109
	Great Arc Series, Section 8° to 18°	90
	South-East Coast and Ceylon Series	24½
	Madras Meridional and Coast ,,	38
	Mangalore Meridional ,,	15
	South Konkan Coast ,,	4
	Volume V—Corrigendum	1
	TOTAL	544½
		Pages.
For Synoptical Volumes	Jodhpore and East Sind Meridional Series	18
	Great Arc Meridional Series, Section 8° to 18°	6
	Madras Meridional and Coast Series	24
	South-East Coast and Ceylon ,,	16½
	Mangalore Meridional ,,	15
	South Párasnáth and South Malúncha Series	2½
	Jogitila Series	1
	South Afghanistan Triangulation	½
	TOTAL	83½
Miscellaneous	Spirit-levelled Heights, Nos. 2 and 3, Bombay Presidency	53
	Ditto ditto. No. 1, Madras Presidency	265
	Letter-press for Chart-headings and foot-notes	51
	Auxiliary Tables	203
	Orders, Memoranda, Forms, &c.	107½
	For Forest Department	28½
	,, Quartermaster General's Department	4½
	TOTAL	712

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Type-printing Section during the Survey year, 1st October 1885 to 30th September 1886.

DR. CR.

	R	R		R	R
Superintendence	920		Letter-press, forms, diagrams, &c., for the Survey of India Department	13,974	
Establishment	7,121				
Aid rendered by Computing Section	5,209				13,974
Wear and tear of plant	573				
Contingencies	59				
		13,927			
Stores received from England	*85				
		85	Miscellaneous letter-press, &c., extra-departmental	202	
Stores purchased in India					202
Stationery from Stationery Office	*164				
		164			
TOTAL		14,176	TOTAL		14,176

* Financial year 1885-86.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Statement of Departmental Work done by the Type-printing Section between 1st October 1885 and 30th September 1886.

Specification of print.	No. of pages.	Total No. of pulls.	No. of copies*.	Value.
				R
Professional Volumes	318	61,279	510	5,338
Synoptical ,,	64	7,714	360	544
Pamphlets of Spirit-levelled Heights	262	21,534	510	3,527
Letter-press for Charts, map-headings and foot-notes	121	3,404	28	439
Auxiliary Tables	141	45,581	1,012	2,751
Forms	56	8,830	176	582
Miscellaneous work done for the Trigonometrical Branch	205	21,041	112	743
TOTAL	†1,167	169,383	...	13,974

* Approximate number.
† Equal 1,306 pages of standard (foolscap) size.

Statement showing the Amount and Value of work done for other Departments by the Type-printing Section between 1st October 1885 and 30th September 1886.

Name of other Departments.	No. of pages.	Total No. of pulls.	No. of copies.	Value.
				R
Forest Department	32	2,477	112	194
Quarter Master General's Department	6	46	7	8
	*38	2,523	...	202

* Equal 32 pages of standard (foolscap) size.

Statement of Expenditure (Dr.) and Amounts Credited (Cr.) on account of the Drawing Section, during the Survey year, 1st October 1885 to 30th September 1886.

DR. CR.

	R. a.	R a.		R a.	R a.
Superintendence	4,800 0		Maps, Charts, &c., for the Survey of India Department	30,126 11	
Establishment	29,464 0				30,126 11
Contingencies	223 0				
		34,487 0	Maps, &c., Extra-departmental	4,503 15	
Stationery from Stationery Office	143 10				4,503 15
		143 10			
TOTAL	...	34,630 10	TOTAL	...	34,630 10

Statement showing the Value of Work done for other Departments by the Drawing Section, from the 1st October 1885 to the 30th September 1886.

Name of other Departments.	Value.	REMARKS.
	R a.	
For the North-Western Provinces Government	72 0	
,, Foreign Office	68 11	
,, Quarter Master General	4,342 0	
,, Forest Department	21 4	
TOTAL	4,503 15	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Departmental Work done in Drawing Section, from 1st October 1885 to 30th September 1886.

Title of Map.	Scale=1 inch.	Remarks and Progress.
Final Charts of Triangulation.		
Assam Longitudinal Series Degree Sheets Nos. 1 to 28	4 miles	In course of preparation.
Jodhpore Meridional Series	4 "	For reduction to half scale. Ready for the Press.
Reduction Chart of Eastern Sind Meridional Series, for Vol. IVA.	6 "	For reduction to half scale. Published.
Compilations.		
Mussooree and Landour Guide Map	1 "	In course of preparation.
Spirit Levelling Operations, Nos. 2 and 3, Bombay Presidency (revised edition)	6 "	For reduction to half scale. Published.
Spirit Levelling Operations, No. 1, Madras Presidency (revised edition)	6 "	For reduction to half scale. Ready for the Press.
Map of Burma, comprised in South-East Trans-frontier Sheets Nos. 4, 5, 12, 13	16 "	In course of preparation.
Rajputana Survey Sheet No. 260 (new numbering) second edition	1 "	Ditto ditto.
Miscellaneous.		
Graticular sheets. South-Western Asia λ 24° to 42° (9 sheets)	8 "	Published.
Graticular sheets. North-West Trans-frontier, λ 24° to 28° and λ 32° to 36° (4 sheets)	8 "	Ditto.
Graticular sheets. North-East Trans-frontier, λ 24° to 32° (4 sheets)	8 "	Ditto.
Graticular sheets. Northern Trans-frontier, λ 26° to 32° (3 sheets)	8 "	Ditto.
Graticular sheets. South-Western Asia, λ 28° to 32° (4 sheet)	16 "	Ditto.
Graticular sheets. North-West Trans-frontier, λ 24° to 36° (3 sheets)	16 "	Ditto.
Graticular sheets. North-East Trans-frontier, λ 24° to 32° (2 sheets)	16 "	Ditto.
Graticular sheets. Northern Trans-frontier, λ 28° to 36° (2 sheets)	16 "	Ditto.
Prepared a Tracing of Afghan Boundary Commission map of country between Mashad and Hari Rud and part of the route from Herat to Kabul, in 3 parts	8 "	For Office use.
Prepared 29 tracings of Afghan Boundary Commission Survey Original Sheets and scrutinized the same	4 & 8 "	Ditto.
Examined 10 photo-zincographed copies of Afghan Boundary Commission Survey maps, received from Survey of India Office, against original sheets corrected by Afghan Boundary Commission Survey, and entered corrections on photo-zincographed copies	4 & 8 "	Ditto.
Prepared an Index to Afghan Boundary Commission Survey and Survey of India Office maps	32 "	Ditto.
Prepared a Tracing of the Index to the Sheets of North-East Transfrontier, and North Trans-frontier, Darjeeling and Nepal Boundary Survey	16 "	Ditto.
Prepared Tracings of Trigonometrical points falling in Sheets 12 and 13 of North-West Trans-frontier	8 "	For use of a Sub-Surveyor proceeding to join the Afghan Boundary Commission.
Prepared Tracings of Baluchistan Survey Charts	4 "	For Office use.
Examined and touched up names on silver prints of map of Turquie d'Asie	About 24 "	Ditto.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Departmental Work done in Drawing Section, from 1st October 1885 to 30th September 1886—contd.

Title of Map.	Scale=1 inch.	Remarks and Progress.
Miscellaneous—contd.		
Prepared a List of Materials available for sheets of South-West Asia and drew their limits on Index Maps	128 miles	For office use.
Prepared a List of data for Map of Burma and China	...	Ditto.
Determined Magnetic Curves applicable to Trans-frontier Maps	...	Ditto.
Correcting Photo-zincographed copies of the Index to the North-East Trans-frontier Sheets to show Pemberton's route in Bhutan and Lama's route in Tibet	64 miles	In course of preparation.
Transliterated Russian names on Sheet 2 of North-West Trans-frontier	8 ,,	For office use.
Collating Geological Notes for Trans-frontier and South-West Asia Maps	...	Ditto.
Prepared Specimens of Printing for Trans-frontier Sheets	...	Ditto.
Prepared Tracings of Routes from Chitral to Gakuch *viâ* Mastuj, Yasin, &c., by Colonel Woodthorpe	4 miles	Ditto.
Prepared a rough plot of Explorer M. H.'s route in Nepal and Tibet from Dagmára Thana to Tribeni Ghât on 2 inches=1 mile; and adjusted the same between obligatory points	4 ,,	For report. In course of preparation.
Examined dispersion of error in Lama U. G.'s traverses in North-Eastern Trans-frontier Sheets Nos. 6 and 7	...	
Computed and corrected Nain Sing's Traverse of 1865-66	...	
Assisted the office of the Himalaya Party in drawing Colonel Tanner's Sketch Map of Sikhim, Darjeeling, &c., and Charts	4 miles.	
Compared Colonel Gerard's Route Map of Kurdistan with his itinerary	16 ,,	For office use.
Corrected Original Sections of Gujarat Survey Sheet No. 41	½ mile	For publication.
Examined and corrected Rajputana Survey Sheets Nos. 73, 74, and 75	1 ,,	Published.
Examined and corrected Sheets Nos. 1 to 8 of Jeypore City and Environs	⅛ ,,	Ditto.
Examined Original Sheets Nos. 6 and 7, of Ajmere City, and prepared the heading and index for this set of maps	1/12 ,,	In course of preparation.
Examined Mirzapur Survey Sheet No. 201 N. E.	½ mile.	
Examined Mirzapur Survey Sheet No. 200	1 ,,	
Examined Nepal Boundary Survey Sheets Nos. 44 and 45, 2nd edition	1 ,,	Published.
Map of Kishenganga Valley	About 4 miles	For correction of Atlas Sheet No. 28.
Projected the few points fixed in 1882-83 on Secondary Triangulation Charts of the Burma Party, Season 1876-77	4 miles	For office record.
Prepared 7 plates of figures of the Great Arc Series from λ 8° to 18° for reduction to half scale	Various	For publication in Professional Volumes.
Prepared 2 plates of figures of the Jodhpore Meridional Series	6 miles	Ditto ditto.
Prepared 2 plates of figures of the Eastern Sind Meridional Series	6 ,,	Ditto ditto.
Drew boundaries of districts in Bombay Longitudinal and Mangalore Meridional Series Preliminary Charts	4 ,,	For use of Computing Section.
Engaged on Charts showing Snowy Peaks on the Himalayas from Assam to the Kunar River	16 ,,	For Australian Geographical Society.
Prepared Monthly Diagrams of conspicuous Sun-spots from October 1885 to August 1886	...	Published in Survey Notes.
Constructed Scales of Latitudes and Longitudes and Miles between the parallels of latitude 0° to 40°	4 and 8, 16 and 32 miles combined	Published.
Drew plan and elevation of New Observatory Building	3 feet	For office use.
Maps, colored. No. of copies — 3,557	...	The coloring this year has been specially heavy.
Supervising Sub-surveyors re-surveying parts of Mussooree and Landour for the new edition of the Guide Map	⅛ mile	In course of preparation.
Prepared one copy of General Report, South-West Baluchistan, Season 1884-85		For Baluchistan Party.
Prepared Introduction to General Report, South-West Baluchistan, and compared the same		For Baluchistan Party.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Statement of extra departmental work done by the Drawing Section.

Title of Map.	Scale=1 inch.	Remarks and Progress.
Compilation, Mapping, &c.		
Completed Map of Dehra Dún and Siwáliks, Sheet No. 2, by insertion thereon of south-western portion of Tiri Garhwál	1 mile	For Executive Engineer, Dehra Dún, completed.
Corrected Colonel Tanner's Sketch Map of Sikkim, Darjeeling, &c.	4 miles	For Foreign Office.
Adjusted and mapped a confidential exploration route falling into six Trans-frontier Sheets	8 „	For the Quartermaster General of India.
Prepared Skeleton Map to illustrate the diary of a confidential route exploration	32 „	Ditto ditto.
Prepared vertical sections of a confidential route	Horizl. 9 miles. vertl. 3,000 ft.	For the Quartermaster General of India.
Prepared a Diagram (Appendix B), illustrating the system of working on a confidential route	6 miles	Ditto ditto.
Prepared Map of country between Umballa and Delhi	About 4 miles	Ditto ditto.
Prepared Tracing of the work done by the Gilgit Mission	4 „	Ditto ditto.
Plotted and reduced route survey by Abdul Jalil, explorer, from Shah Kadar *viâ* Jelalabad, Asmar, &c., to Malta	1 „	Ditto ditto.
Completed with respect to headings and foot-notes, Forest Maps, before sending to Press	Various	For Forest Department.
Coloring Maps.		
North-East Trans-frontier Sheet No. 6, in four sections, 24 sets	4 miles	For Foreign Office.
Colonel Tanner's Sketch Map of Sikkim, Darjeeling, &c., 26 copies	4 „	Ditto.
Sketch Map of a Journey in the Pamir and Upper Oxus, 40 Copies	12 „	Ditto.
Map of the Country between Gilgit Fort and Khomar Nala, 12 copies	6 „	Ditto.
Work done with Gilgit Mission by Colonel Woodthorpe, 6 copies	4 „	Ditto.
Map to illustrate Report on Sind-Kalat Boundary, 30 copies	1 „	For Commissioner of Sind (F. O.)

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Photo-zincographic Section, during the Survey year 1st October 1885 to 30th September 1886.

DR. CR

	₹ a.	₹ a.		R a.	₹
Superintendence	2,400 0		Maps, Forms, Diagrams, &c., for the Survey of India Department	11,078 1	
Establishment	8,806 0				
Contingencies	151 11				
		11,357 11			11,078 1
Chemicals and Stores from England	2,111 9				
Paper received from England	3,759 3				
		5,870 12	Miscellaneous Maps, Plans, &c., extra departmental	5,583 7	5,583 7
Chemicals and Stores purchased in India	52 3				
Stationery (paper) from Stationery Office	618 3				
		670 6	Balance to debit of Department	...	1,261 2
Shipping and Landing charges	23 13	23 13			
TOTAL	...	17,922 10	TOTAL	...	17,922 10

Note.—In addition to the credits above shown, the section has realized (by sale *on payment* of maps, &c.) and paid into the Treasury the sum of ₹663-7.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*contd.*

Statement shewing the Amount and Value of work done for other Departments by the Photozincographic Section between 1st October 1885 and 30th September 1886.

Names of other Departments.	Photozincographic Printing.						Type Printing.				Value.	Remarks.
	No. of Sheets or Sections or subjects.	No. of Negatives.	No. of Photo. transfer Prints.	No. of Zinc Plates.	No. of Silver Prints.	No. of Blue Prints.	No. of Pages or Items.	No. of Copies.	No. of Pulls.	No. of Copies.		
											Rs. a. p.	
Foreign Department	10	41	41	11	...	4	...	...	...	...	639 15	
Forest Department	67	208	269	48	37	554	...	...	5,582	6,782	4,219 6	
Quarter Master General	2	9	42	6	...	...	...	...	2,275	2,300	678 11	
Secretary to Government, N.-W. P. and Oudh, Irrigation Branch	2	3	3	2	...	...	...	...	50	50	45 7	
Total		261	355	66	37	558	...	...	7,907	9,132	5,583 7	

Statement of Departmental work done by the Photo-zincographic Section between 1st October 1885 and 30th September 1886.

Specification of Plate or Print.	Photozincographic Printing.									Type Printing.		Total No. of pulls.	No. of copies.	Value.			Remarks.
	Progress made	Scale of maps.	Size of each sheet.	No. of sheets, sections or subjects.	No. of negatives.	No. of photo. transfer prints.	No. of zinc plates.	No. of silver prints.	No. of blue prints.	No. of pages or items.	No. of copies.			R	a.	p.	
		1 inch=															
Nepal Boundary Survey, Sheet No. 28	F.	1 mile.	D.E.	1	...	...	...	...	...	...	...	53	53	6	15	0	} Final issue.
Do. do. Sheets Nos. 20 to 43	,,	4 ,,	,,	15	90	90	15	...	...	...	...	805	805	1,806	14	0	
Do. do. ,, Nos. 44 and 45	,,	1 ,,	,,	2	16	16	2	...	...	...	...	155	155	306	3	0	
Do. do. Mechi Sheets Nos. 1 to 4	,,	4 ,,	,,	4	24	24	4	...	30	...	...	30	30	463	12	0	} For use of Field Party.
Darjeeling Survey, Daling Hills Sheets Nos. 1 to 7, skeleton	,,	2 ,,	,,	7	46	46	7	...	32	...	...	32	32	168	6	0	
Gujarat Survey, Sheets Nos. 40 and 49	,,	4 ,,	...	2	8	...	...	32	...	...	...	...	8	95	0	0	Atlas reductions for Engravers.
Do. ,, No. 50, Sec. 11	,,	2 ,,	½ D.E.	1	2	2	1	6	4	...	...	8	11	54	10	0	For use of Field Party.
Do. ,, No. 59, Sec. 11	,,	4 ,,	D.E.	1	8	9	1	...	...	...	...	86	86	171	14	0	
City of Jeypore with Amer, Sheets Nos. 1 to 8	,,	2 ,,	,,	16	84	84	16	...	...	...	...	1,184	592	1,772	15	0	In *two* colours.
Rajputana Survey, Sheets Nos. 73, 74, 75.	,,	1 ,,	,,	3	18	18	3	...	...	...	...	469	469	444	11	0	
Do. do. Nos. 73, 74, 75	,,	4 ,,	...	3	3	...	...	12	...	...	...	...	12	23	5	0	Atlas reductions for Engravers.
Do. do. No. 56 E.	,,	2 ,,	...	1	1	...	...	3	...	...	...	...	3	12	7	0	} For use of Field Party.
Gwalior and Central India Survey, Sheets Nos. 227, 228, 230; 208, 224, 207, 223; 227 in 2 parts	,,	2 ,,	...	5	5	...	...	20	...	...	...	...	20	73	8	0	
Graticule Sheets, *with trigonometrical points*, North-West Trans-frontier, Nos. 14, 21, 22	,,	8 ,,	D.E.	3	18	18	3	...	27	...	...	42	42	320	5	0	
Graticule Sheets, *blank*, North-West Trans-frontier; 24° to 26°, 26° to 28°, 28° to 30°, 34° to 36°	,,	8 ,,	,,	4	6	6	4	...	...	...	...	78	78	133	4	0	
Do. ,, North Trans-frontier; 26° to 28°, 28° to 30°, 30° to 32°	,,	8 ,,	,,	3	...	...	3	...	...	...	...	49	49	11	8	0	
Do. ,, North-East Trans-frontier; 24° to 26°, 26° to 28°, 28° to 30°, 30° to 32°	,,	8 ,,	,,	4	...	...	4	...	...	...	...	103	103	23	11	0	
Do. ,, South-West Asia, 24° to 26°, 26° to 28°, 28° to 30°, 30° to 32°, 32° to 34°, 34° to 36°, 36° to 38°, 38° to 40°, 40° to 42°	,,	8 ,,	,,	9	20	20	9	...	...	...	...	382	382	505	3	0	
Do. ,, North-West Trans-frontier; 24° to 28°, 28° to 32°, 32° to 36°	,,	16 ,,	,,	3	18	18	3	...	12	...	...	40	40	290	2	0	
Do. ,, North Trans-frontier, 28° to 32°, 32° to 36°	,,	16 ,,	,,	2	...	...	2	...	...	...	...	27	27	7	3	0	
Do. ,, North-East Trans-frontier, 24° to 28°, 28° to 32°	,,	16 ,,	,,	2	...	...	2	...	...	...	...	27	27	7	3	0	
Do. ,, South-West Asia, 28° to 32°	,,	16 ,,	,,	1	...	...	1	...	...	...	...	26	26	7	12	0	
North-East Trans-frontier Sheet No. 5	,,	8 ,,	,,	1	6	6	1	...	...	...	...	60	60	99	5	0	Preliminary prints.
Do. do. No. 6	* ,,	...	...	1	...	...	1	...	12	...	...	12	12	3	12	0	
Northern Trans-frontier Sheets Nos. 20 and 21	,,	8 miles	D.E.	2	12	12	2	...	...	...	...	120	120	198	10	0	Do. do.
Kishenganga Valley, Kashmir	,,	4 ,,	½ ,,	1	2	2	1	12	...	...	...	2	14	77	13	0	Including Atlas reductions for Engravers.
Turkestan Confidential Edition, Sheets 1, 2, 4	* ,,	32 ,,	D.E.	3	...	...	3	...	...	...	...	90	90	20	10	0	
Eastern Afghanistan and Kafiristan	* ,,	16 ,,	½ ,,	1	...	...	1	...	...	...	...	12	12	1	14	0	
Eastern Turkestan, 1873-74	* ,,	40 ,,	D.E.	1	...	8	1	...	...	...	...	306	306	122	1	0	
Kandahar District Triangulation, season 1880-81, Finl Chart	,,	8 ,,	½ ,,	1	4	4	1	...	...	...	...	136	136	90	7	0	For Synoptical Volume IA.
Diagram of North-West Quadrilateral	,,	64 ,,	½ ,,	1	1	2	1	...	...	...	...	78	156	38	1	0	Do. do.
Diagram of figures (polygonal) of the Jodhpore and Eastern Sind, Meridional Series	,,	12 ,,	½ ,,	4	4	8	4	...	...	...	...	7,660	2,120	215	0	0	For Professional Volume IVA.
Reduction of Chart of principal Triangulation of the Eastern Sind Meridional Series	,,	12 ,,	½ ,,	1	2	2	1	...	...	...	...	530	530	55	7	0	Do. do.
Diagram shewing Triangulation connecting Fyzabad Longitude Station	In Press.	1 ,,	½ ,,	1	2	4	1	...	...	...	...	100	200	56	2	0	For Professional Volume of Electro-telegraph longitudes.
Diagram of figures (polygonal of the Great Arc Meridional Series.	F.	6 and 12 miles.	½ and ½ D.E.	5	5	14	5	...	...	...	...	875	2,500	270	7	0	For Professional Volume of Southern Trigon.

Principal chains of triangles west of the meridian of 92°		200 miles	¼	D.E.	1	1	2	1	...	...	...	...	250	500	35	5	0	For Professional Vol. IVA.
South-West Asia Index (corrected)	*	28 "		D.E.	1	...	1	1	...	...	...	...	35	35	7	8	0	
Do. do.		320 "	¼	F.P.	1	1	2	1	...	...	...	...	264	528	47	14	0	
Chart of Spirit-levelling Operations, seasons 1877-80		24 "	¼	D.E.	1	2	2	1	...	...	...	...	530	530	71	9	0	For pamphlet of Spirit-levelled Heights Nos. 2 and 3, Bombay Presidency and Nizam's Dominions (Revised edition.)
Diagram shewing lines of levels in South India		200 "	1/16	"	1	1	8	1	...	...	...	...	125	1,000	66	13	0	For pamphlet of Spirit-levelled Heights.
Dera-Ismail-Khan Frontier	*	2 "		D.E.	1	...	...	1	...	...	...	...	32	32	7	2	0	
Map of North-East Persia		1/2 "		...	1	2	...	...	8	...	...	...	...	4	25	2	0	
Hyderabad Survey Sheets Nos. 220 and 224		1 "		D.E.	2	12	12	2	...	...	...	...	150	150	202	6	0	
Bangalore Cantonment Chart		¼ "		"	1	7	7	1	...	...	...	...	25	25	99	0	0	
Cantonment and City of Bangalore		1/2 "		"	2	12	12	2	...	...	...	...	400	400	251	10	0	
Abstract Account of conspicuous Sun-spots, November 1885 to August 1886		...	½	F.P.	10	10	20	10	...	...	...	...	1,029	2,058	303	4	0	For Survey of India notes.
Russian map of Trans-Caspian region, 1877		20 versts		D.E.	1	8	8	1	...	...	...	...	4	4	153	5	0	For office use.
Map of the Pamir and co-terminous countries		20 miles		...	1	6	...	...	18	...	...	...	...	3	74	11	0	
Asiatique deL'Empire Ottoman		24 "		...	1	20	...	...	60	...	...	...	...	3	249	0	0	
Katmandu Valley, with key		2 "		D.E.	3	6	6	1	...	6	...	...	9	9	86	3	0	For confidential use.
Afghan Boundary Maps, Nos. 19, 20, 28, 30, 31, 34, 35		4 "		D.E. and ½ D.E.	7	32	32	7	...	..	...	...	35	35	431	13	0	For office use.
Miscellaneous Forms, &c., &c., for departmental use		..		...	22	11	27	22	...	...	...	...	6,638	3,756	762	14	0	
Copies of Maps of "Other Departments" taken for Departmental use.																		
Index Map to the Melghat Taluk Forest Survey		8 miles	½	D.E.	1	1	2	1	...	...	...	...	10	20	2	12	0	Copies retained, *for office record*, of maps, &c., requisitioned for by other departments; the cost of press pulls and stationery being all that is here charged to the Survey Department.
Do. to Forest Survey of Bashahr		4 "		"	1	5	5	1	...	...	...	...	24	24	3	1	0	
Forest map, Berar Forests, part of Sheet No. 14		¼ "		D.E.	1	8	8	1	...	..	..	...	40	40	6	4	0	
Do. of Melghat Taluk, District Ellichpur, Berar, Sheet No. 14 (parts)		¼ "		"	1	6	6	1	..	...	...	...	44	44	8	10	0	
Do. Berar Forests, Sheets I, II & III		¼ "		"	3	18	18	3	...	...	...	...	120	120	28	8	0	
Do. Do. Melghat Taluk, Sheets Nos. 19 and 20		¼ "		"	1	4	4	1	..	...	...	...	44	44	8	10	0	
Do. Do. Sheet No. 15		¼ "		"	1	4	4	1	...	...	...	...	40	40	9	8	0	
Do. of Ellichpore Taluk, Berar		1 "		"	1	6	6	1	...	...	...	...	40	40	9	8	0	
Do. Chota Nagpore, Sheet No. 157 S. E.		¼ "		"	1	7	7	1	...	...	...	...	20	20	4	12	0	
Do. do. do.		1 "	½	"	1	1	1	1	...	...	...	...	10	10	2	9	0	
Kumaun and Garhwál Forest Map No. II		½ "		"	1	2	2	1	...	...	...	...	20	20	2	14	0	
Do. do. do. No. III A. III B., IV & V.		½ "		D.E.	4	24	24	4	...	...	...	...	160	160	38	0	0	
Forest Map of Kumaun and Garhwal, Sheets Nos. 69, 70, 71 and 74		¼ "		"	4	24	25	4	...	2	...	...	176	176	34	8	0	
Kumaun and Garhwál Triangulation Chart No. V		1 "		"	1	6	6	1	...	..	...	...	22	22	4	5	0	
Do. do. do. No. V		2 "	¼	"	1	2	2	1	..	...	...	...	24	24	2	4	0	
Do. do. do. No. VII		1 "		D.E.	1	6	6	1	...	...	...	...	27	27	4	15	0	
Do. do. do. No. VII		2 "	¼	"	1	2	2	1	...	...	...	...	20	20	1	4	0	
Tiri Garhwál Forest Survey Sheet No. 1, Bhagirathi		¼ "		D.E.	1	6	7	1	...	2	...	...	44	44	8	10	0	
Do. do. No. 2, 3 do.		¼ "		"	2	12	12	2	...	...	...	...	80	80	17	10	0	
Ganges Working Circle Forest Map		1 "		"	1	6	6	1	...	...	...	...	20	20	3	2	0	
Kheri and Pilibhit Reserved Forests		4 "	¼	"	1	2	4	1	...	...	...	...	10	20	2	12	0	
Forest Map of Bahraich		4 "	¼	"	1	2	4	1	...	...	...	...	10	20	2	12	0	
Do. Tarhoch		½ "		D.E.	1	4	4	1	...	...	...	...	25	25	2	10	0	
Dehra Dún and Saháránpur Forest Division		4 "	¼	"	1	3	3	1	...	...	...	...	20	20	2	0	0	
Jaunsar Division Forest Map		4 "	¼	"	1	4	4	1	...	...	...	...	20	20	2	0	0	
Deota Sledge road		16 feet	¼	"	1	1	2	1	...	...	...	...	15	30	2	0	0	
Do. do. longitudinal Section		300 "		D.E.	1	4	4	1	...	...	...	...	22	22	4	1	0	
Forest Map of Deota		½ mile.	¼	"	1	1	2	1	..	...	...	...	15	30	1	11	0	
References for Forest Survey Maps		½ "	1/16	"	1	2	2	1	...	..	...	...	3	6	1	5	0	
Country between Umballa and Delhi		4 "		D.E.	1	8	40	5	...	...	...	...	86	86	12	6	0	
Appendix B, illustrating the system of working on a confidential route		6 "	½	F.P.	1	1	2	1	...	...	...	...	5	10	1	4	0	
Trace of work done with the Gilgit Mission		¼ "	½	D.E.	1	4	4	1	...	...	...	...	8	8	2	12	0	
Sind-Kalát Boundary Survey		1 "		D.E.	1	8	8	1	...	...	...	...	25	25	3	4	0	
Nadrai Aqueduct Foundation Plan		40 feet	½	"	1	3	3	1	...	...	...	...	23	23	2	15	0	
TOTAL	...	...	...	...	25	722	790	202	171	127	...	...	16,774	19,718	11,077	1	0	

* Additional points of previous publications. D.E. represents Double Elephant; F.P. represents Foolscap. F‖ Finished.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN—*concld.*

Statement of Expenditure (Dr.) and Amounts credited (Cr.) on account of the Solar Photography Section, during the Survey year 1st October 1885 to 30th September 1886.

DR.	₹ a.	₹ a.	CR.	₹ a.
Superintendence	600 0		Value of Negatives and Silver prints taken for the Solar Physics Committee, under authority from the Secretary of State for India (debitable to the Industry, Science and Art Department)	9,820 13
Solar Photographer	6,000 0			
Establishment	269 0			
Contingencies	1,371 0	8,240 0		
Chemicals and Stores received from England	1,520 0	1,520 0		
Chemical and Stores purchased in India	50 13	50 13		
Shipping and Landing Charges	10 0	10 0		
TOTAL	...	9,820 13	TOTAL	9,820 13

Table of Working Facts for the year 1885-86.

1885-86.	Number of Days.				Number of Negatives.								Number of working days when Solar Phenomena were	
		Failures.			Solar Phenomena.									
	When Negatives were taken.	From bad weather.	From various causes.	Total.	Spots and Faculæ.		Spots only.		Faculæ only.		Total.		Visible.	Absent.
					8″	12″	8″	12″	8″	12″	8″	12″		
October	31	...	...	31	55	20	...	...	2	1	57	21	31	
November	30	...	...	30	47	22	...	...	7	2	54	24	30	
December	26	5	...	31	39	18	...	...	10	1	49	19	26	
January	18	13	...	31	23	6	...	...	12	4	35	10	18	
February	24	4	...	28	44	10	...	...	1	..	45	10	24	
March	22	9	...	31	38	12	...	...	...	...	38	12	22	
April	27	3	...	30	51	16	1	...	1	...	53	16	27	
May	22	9	...	31	34	...	...	...	7	...	41	...	22	
June	25	5	...	30	43	...	...	...	2	..	45	...	25	
July	15	16	...	31	26	...	...	...	1	...	27	...	15	
August	20	11	...	31	28	...	...	...	2	...	30	...	20	
September	30	...	...	30	40	3	...	...	11	...	51	3	30	
TOTAL	290	75	...	365	468	107	1	...	56	8	525	115	290	

One thousand and four silver prints of the 8-inch and 127 of the 12-inch pictures were prepared; and weekly despatches of both silver prints and negatives made as usual to the India Office.

Table of Percentages of daily Visibility of the Sun and the presence of features.

Year.	In 100 days the Sun was invisible on	In 100 days features were present on
1877-78	9 days (obtained from 273 days).	30 days (obtained from 248 working days).
1878-79	11 ,, ,, 89 ,,	28 ,, ,, 79 ,,
1879-80	14 ,, ,, 289 ,,	82 ,, ,, 232 ,,
1880-81	15 ,, ,, 365 ,,	96 ,, ,, 307 ,,
1881-82	10 ,, ,, 365 ,,	100 ,, ,, 328 ,,
1882-83	13 ,, ,, 365 ,,	100 ,, ,, 318 ,,
1883-84	21 ,, ,, 366 ,,	100 ,, ,, 285 ,,
1884-85	22 ,, ,, 365 ,,	100 ,, ,, 284 ,,
1885-86	21 ,, ,, 365 ,,	100 ,, ,, 290 ,,

Contrasting the percentages of days of invisibility above given with those for Greenwich, as furnished by Astronomer Royal's Reports, we have:—

Year.	At Dehra, year ending 30th September.	At Greenwich.
1880-81	15	60 }
1881-82	10	45 } Year ending 20th May.
1882-83	13	45 }
1883-84	21	41 } Year ending 31st De-
1884-85	22	58 } cember.
1885-86	21	

Government of India Central Printing Office.—No. 13 S. G.—20-4-87.—425.

File No. 56.
Serial No. 8.

1887.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

Circular No. $\frac{39. S.}{56—8.}$

Dated Simla, the 19th July 1887.

SUBJECT.

REMARKS on the Report of the Survey of India Department for 1885-86.

Government of India Central Printing Office.—No. 147 R. & A.—26-7-87.—925.

Circular No. $\frac{39. S.}{56-8.}$

Extract from the Proceedings of the Government of India, in the Revenue and Agricultural Department (Surveys), under date Simla, the 19th July 1887.

READ—

The General Report on the Operations of the Survey of India Department for the year 1885-86.

RESOLUTION.

DURING the greater portion of the year, the administration of the Department was in the hands of Lieutenant-Colonel H. R. Thuillier, R.E., Colonel G. C. DePrée, S.C., the Surveyor General, having been obliged in February 1886 to proceed on furlough to England owing to ill-health. Intimation of the death of Colonel DePrée has recently been received with regret. After a service of 37 years in India, in nearly 33 years of which Colonel DePrée was connected with the Survey of India Department, he was about to retire on pension.

Colonel J. Sconce, S.C., resumed charge of the superintendence of Revenue surveys on his return from furlough in March 1886. Several changes took place in the personnel of the Head-Quarters Offices, owing to the departure on leave of Lieutenant-Colonel Waterhouse, and Majors C. Strahan and M. W. Rogers. Colonel C. T. Haig, R.E., continued to superintend the Trigonometrical Branch at Dehra.

2. The first part of the Report contains a summary of the operations of the year, while detailed accounts of the work of the several parties are given in Part II. The different operations were carried on by 25 parties, *viz.*, one Coast Triangulation, 10 Topographical, 6 Cadastral, 5 Traverse, 1 Geographical, and 2 Astronomical parties. Before remarking on the work accomplished, it may be observed that the old system of naming each party according to the province, district, or other locality in which it is employed, has been given up, and all the parties have now been serially numbered. The number now given to each party will be borne by it as long as it exists and in whatever locality it may be employed.

Secondary Coast Triangulation.

3. Secondary triangulation was carried along the east coast from Coconada to Masulipatam. The total distance triangulated was 145 miles; and the positions of 9 beacons, besides 7 other permanent marks, fixed for the use of the Marine Survey Department.

4. Three out of the 10 Topographical parties completed the surveys on which they had for some years been respectively engaged in the Andaman Islands, Cutch, and Mysore.

Andaman Islands.

5. The survey of the Andamans has been executed generally on the scale of $\frac{1}{2}$ inch = 1 mile, with special portions round the Port Blair Settlement on the 4-inch scale. The surveys cover all the islands excepting a large part of Little Andamans, where a survey was impracticable. The Governor General in Council is pleased to observe the commendation again bestowed on Captain Hobday and his assistants, both by the Officiating Surveyor General, and also by the Superintendent of Port Blair and the Nicobars. His Excellency also desires to express his thanks to the local authorities for the valuable assistance rendered to the survey party, to which the success of the operation is said to be largely due.

Cutch.

6. In addition to Cutch, the adjacent Rán, the peninsula of Nagar Párkar, and small portions of North Gujarát have been topographically surveyed.

Mysore.

7. The Mysore Survey was commenced in November 1875, and has therefore lasted for 11 years. The operations were, however, greatly impeded during the first three years by famine, and the outturn of work during that period by two full parties was only 4,701 square miles. Since November 1877 only one party has been at work and has completed the remaining large area of 26,238 square miles.

8. Three parties worked in the Bombay Presidency in the Deccan and Gujarát Districts and the Southern Mahratta Country.

Deccan.

The Deccan party surveyed a total area of 1,675 square miles, lying partly in the Kolába, Ratnagiri, and Satara Districts, and partly in the Kolába, Kolhápur, and South Mahratta Agencies. Some traversing, and the forest boundary survey in the Kolába and Ratnagiri Districts, was also executed. After the close of the year's work, the party was transferred to the Central Provinces for the prosecution of Revenue surveys. An area of 11,953 square miles has been left unfinished in the Deccan, which must lie over until the Revenue surveys required in connection with Settlement operations in the Central Provinces and elsewhere have been completed.

Gujarát.

9. The Gujarát party surveyed a total area of 2,524 square miles, besides triangulating 749 square miles and traversing with the theodolite 422 linear miles. A small party was also attached to the Special Commission appointed to settle the boundary dispute between Baroda and the Dangs States, when some boundary surveying was accomplished.

South Mahratta.

10. The South Mahratta party surveyed an aggregate area of 1,672 square miles, lying chiefly in Belgaum, but partly in the Dhárwár District and some neighbouring Native States. The skeleton traverse survey of the forests of six villages in Khánápur taluka was completed, and the work partially done for six other villages. A large area was also triangulated and traversed in advance for the next season's topography.

Mirzapur.

11. The party employed on the Mirzapur Survey has carried out the following operations :—

(*a*) the Detail survey of 487 square miles on the scale of 2 inches=1 mile, and 194 square miles of triangulation;

(*b*) the Revenue survey of village boundaries in the Dudhi Pargana;

(*c*) the setting up of the theodolite at 6,419 stations, embracing 1,172·6 miles of traverse. This work has proved that, with the aid of traverses, village maps can be utilised for the compilation of standard topographical sheets;

(*d*) the completion of records and General Reports of the Bhopal-Malwa and the Khandesh and Bombay Native States surveys.

Rajputana.

12. In Rajputana 3,540 square miles were surveyed on the $\frac{1}{2}$-inch scale in portions of Jodhpore and of the Maláni Districts near Bármer and the Luni river. On the scale of 1 inch=1 mile an area of 256 square miles was surveyed in a tract lying on the junction of the boundaries of the Jodhpore, Sirohi, and Pálanpur States. Triangulation in advance covered an area of 5,850 square miles. The village boundary sheets of the Ajmere-Merwara Survey were revised, and the district maps compiled.

Baluchistan.

13. In Baluchistan, one party was employed principally in work of a special nature for the requirements of the Military Department. The country surrounding Quetta was surveyed on the 2-inch scale, and also a portion of the Khwaja-Amran mountains, extending from the Ghwája Pass on the south to the Bogra Pass on the north. The routes between the Registan and Baluchistan were also explored, and very fair progress was made in the operations for the regular topographical survey of the country.

14. One Topographical party continued the Forest surveys in Burma. The Detail survey, partly on the 4-inch scale and partly on the scale of 2 inches =1 mile, covered a total area of 330 square miles of forests, extending over the greater portion of the tracts drained by the Taungnyo river in the Tharrawaddy District and the Shwele river in the Prome District. The survey was also carried over the Shwedaung hills to the south of Prome. The triangulation of the year covered an area of 263 square miles, and the traverse survey 345 square miles. The outturn was smaller than in the preceding year, but this is accounted for by the fact that work was greatly impeded during the year under review by the unsettled state of the province, and by the withdrawal of some of the Surveyors for survey operations required in Upper Burma. Burma Forest Survey.

15. The six Cadastral parties were employed in the districts shown in the following tabular statement, in which the total outturn of work of each party and particulars of cost of operations are also shown:— Cadastral Surveys.

Province.	District.	Area surveyed.	Average cost per square mile in 1885-86.				Average cost per square mile in 1884-85.			
			Traversing.	Detail surveying.	Record-of-rights, Khanapur.	Completion of records.	Traversing.	Detail surveying.	Record-of-rights, Khanapur.	Completion of records.
		Sq. M.	*R*	*R*	*R*	*R*	*R*	*R*	*R*	*R*
Burma	Akyab	661	60·2	183·9	...	...	78·5	205·6	...	...
North-Western Provinces	Gorakhpur	320	20·5	70·5	30·5	33·5	16·8	66·3	34·3	43·9
Ditto Ditto	Basti	783	22·6	33·4	40·5	47·0	21·4	37·9	61·7	53·5
Central Provinces	Bilaspur	763	16·1	70·1	82·0	...	...	...	...	...
Assam	Kamrup	468	33·4	94·2	66·6	...	31·8	92·3	42·8	48·3
Bengal	Mozufferpore	414	28·8	97·1	59·5	69·5	...	...	...	...

16. The tracts surveyed in the Akyab District are very much scattered, but mainly lay on the borders of the Kaladan and Padu rivers, east and north of the town of Akyab; while other tracts were situated in the valleys to the north-west of the district. Akyab.

17. In Gorakhpur District the Hata and Paranna tahsils were cadastrally surveyed, and, in addition, 41·07 square miles in the Sarun District in Bengal were surveyed topographically. Some changes were made in the system of cadastral surveys adopted in Gorakhpur, and will, it is believed, have the effect of accelerating the work and of saving some of the expenditure hitherto incurred by the Settlement Department. Gorakhpur.

18. The Cadastral operations of the Basti party were confined to the Basti and Khalilabad tahsils. A survey on the 4-inch scale of the villages on the right bank of the Gogra river was also effected. Basti.

19. The surveys in Bilaspur were carried out on the Gorakhpur system. The Surveyors were new to the work, and there were other reasons which tended to make the average cost higher than in Gorakhpur, but it is confidently expected that lower rates will be exhibited as the result of the next season's working. Bilaspur.

20. The operations of the year brought to a close the Cadastral survey of the Kamrup District; some preliminary traversing was also done for the survey of the Darrang District. Kamrup.

21. In the Mozufferpore District the Cadastral survey and record-of-rights were completed in Tappa Chakla Nosi (except 3 or 4 square miles within the Mozufferpore Municipality), and in Tappa Bhatsala (except an area of 90 square Mozufferpore.

miles). The cost rate of the operations, as shown above, is high as compared with that of similar work in other districts; but it includes several items of extraordinary expenditure, such as travelling allowances, carriage of equipment, cost of new tents, &c., amounting to ₹14,129. The detailed nature of the work, rendered necessary by local peculiarities, also tended to make the survey more expensive than in the North-Western Provinces traverse surveys.

Traverse Surveys, Ajmere.

22. Three-and-a-half full parties have been employed during the year under report. A detachment from one of these completed the survey of 51 jagir and of six minor istimrar villages in Ajmere, covering an area of 243 square miles.

Punjab.

23. The Punjab party resumed work in the Ludhiana and Umballa Districts, and extended them to the Jullundur, Hoshiárpur, and Gurdáspur Districts and to the Kapurthala State. The total outturn of work was :—

Traversing	3,770	sq. miles.
Mapping by reduction	1,922	„
Area tested	2,920	„
Area finally mapped	2,624	„

Central Provinces.

24. The remaining traverse parties were employed in the Central Provinces and surveyed a total area of 5,269 square miles in the Raipur, Sambalpur, Jubbulpore, and Damoh Districts. The operations in these districts consisted of a simple skeleton traverse survey, which will form the basis of complete skeleton maps, on which the patwaris will plot their measurements of the fields. The "field block" system of survey, which had been tried for two previous seasons in the Raipur and Sambalpur Districts, proved a failure, and has been finally abandoned.

Geographical and Miscellaneous. Himalaya party. Nipal boundary demarcation.

25. The Himalaya party was employed in continuation of the preceding years' operations on the Topographical survey of the Hill States about Simla and of the Kangra District, and on the demarcation of the Nipal-Bengal boundary on the Mechi river. Twenty-four miles of the boundary was demarcated, the erection and numbering of pillars being left over to be taken up on completion of the entire line of boundary. The party also undertook to bring up the arrears of mapping connected with the Nipal Boundary Survey, the Sikkim Triangulation, and the Darjeeling Revisionary and Dahing Lands surveys. Very little progress was, however, made, and the arrears of mapping and computations were transferred to the Trigonometrical Branch for completion.

Kangra and Simla Hill States.

26. The following is the outturn of work in Kangra and the Hill States :—

	sq. miles.			
Kangra	300	on the	16	inches=1 mile scale.
Suket, Mandi, Kumhársain and Bashahr States	308	„	2	„
Ditto ditto	238	„	4	„

Geographical Surveys and Reconnaissances.

27. A large quantity of work was done during the year under review under the head of Geographical Surveys and Reconnaissances. Great credit is due to the officers of the Afghan Boundary Commission for the very large area of

Afghanistan.

120,000 square miles surveyed in Afghanistan. The whole of the province of Herat, including the hitherto unknown Taimani and Firozkuhi country, was mapped; almost the entire province of Afghan Turkistan, with a large portion of the Hazara country in the neighbourhood of Bamian, was reconnoitred or surveyed; and, on the return march of the Commission, all the important passes of the Hindu Kush were surveyed.

Gilgit.

28. The surveys executed by Colonel Woodthorpe, R.E., while attached to the Gilgit Mission, afford a mass of valuable information of the districts of Yasin, Chitral, Hunza and Wakkan. Colonel Woodthorpe's services merit the special commendation of the Government of India.

29. The route surveys executed by explorers M.—H. and R.—N. have added largely to the Geographical knowledge of Nepal and Thibet and of Western and Eastern Bhutan, besides affording valuable information regarding the trade routes to Thibet. Explorer R.—N. also made an unsuccessful attempt to obtain accurate information on a long-disputed question as to whether the Brahmaputra or the Irrawaddy is the recipient of the waters of the Sanpo. Trade routes.

30. In Upper Burma Captain Hobday, with a small detachment of Surveyors, made a reconnaissance survey round Mandalay and compiled the reconnaissance sketches executed by officers with the Burma field force. Captain Hobday and a Surveyor joined two Military expeditions, one to the Kachin Hills and the second to the south-east of Mandalay. They succeeded in extending triangulation southwards as far as latitude 21° and in surveying an area of 150 miles on the ½ inch scale. Upper Burma.

31. Tidal observations were taken at 16 ports. Four new observatories were opened during the year at Bhavnagar, Cochin, Coconada, and Chittagong; and three observatories were closed at Diamond-Harbour, Amherst, and Moulmein, where the usual period of five years' registration had been completed. Tidal observations.

32. The spirit-levelling operations consisted of three main lines, (1) along the railway line from Madras, *viâ* Tanjore to Negapatam, (2) from Tanjore, *viâ* Ramnad to Pámban, and (3) from Ramnad to Tuticorin. Three pairs of test bench marks were also embedded in the vicinity of Negapatam, Pámban, and Tuticorin. Spirit-Levelling.

33. The two Astronomical parties resumed the electro-telegraphic observations for the determination of differential longitudes. Nine arcs were measured between stations of the Great Trigonometrical Survey, and observations taken on an experimental arc at Dehra Dun. Astronomical observations.

34. Very satisfactory progress has again been made in the operations of the Drawing, Engraving, Photographic, Lithographic and Mathematical Instrument Offices, full accounts of which are given in Part III of the Report. Head-Quarters Offices.

35. The maps issued numbered 210,288, valued at ₹1,66,749. The income derived from the sale of maps amounted to ₹8,732-14-0. In the Map Drawing Office a great deal of work was executed for the Colonial and Indian Exhibition, among which were a map of the World, exhibiting the Export and Import Trade of India, and maps of India to illustrate Density of Population, Emigration, External Trade, Land Settlements and Revenue, Geology and Religions. Three small skeleton maps were drawn, showing— Maps issued. Special maps.

(*a*) the Burma and Assam Frontier, (*b*) the Punjab and Afghanistan Frontier, and (*c*) the Sind and Baluchistan Frontier.

The district maps required for Administration Reports have all been completed, except two for Assam and two for the Central Provinces, and the Provincial maps have been taken in hand. District and Provincial maps.

36. The total number of Mathematical instruments issued to other Departments was 41,643 and their value ₹1,77,864. The serviceable stock increased during the year by 52,128 instruments, valued at ₹1,70,179. Of these, 13,453 were manufactured during the year at a cost of ₹21,454, and 3,103 instruments were repaired in the Mathematical Instrument Depôt, at a cost of ₹21,378, their value after repairs being estimated at ₹76,039. The account of the Mathematical Instrument Office at page cxviii of the Appendix shows a net profit of ₹3,887-5-0. Mathematical Instrument Office.

37. The principal work of the Dehra Office consists of the final reduction and publication of the various operations of the Great Trigonometrical Survey. Mr. Cole, the Superintendent, has been ably assisted in the work by Mr. Eccles. During the year under notice, the simultaneous reduction of the circuit triangles (South-West Quadrilateral), and the final reduction of Latitude observations taken up to the year 1884-85, were brought to completion. Considerable progress was also made in the secondary triangulation of the southern Dehra Office.

Trigon. The work of Solar photography was continued; 115 large and 525 small-sized pictures of the sun were taken.

38. The Survey Department has, during the year under review, made a considerable advance in the direction of improving its financial value to the State by undertaking work of a positively remunerative character. The most notable operation of this kind is the great Traverse survey of the Central Provinces which, by providing a frame-work for the detailed field plotting of villages by district establishments, will probably enable the Revenue authorities to complete the assessment of about 40,000 square miles, without the loss of a single year's revenue. The performance of this work has thrown a heavy burthen on the Department, which it has borne in an admirable manner, at a time when, for financial reasons, it has been required to contract its establishments, and when the demands for a survey staff on the Boundary Commission, in Upper Burma and in the North-West Frontier, had added to its difficulties. A traverse survey of the same kind was effected in Ajmir, while a large amount of cadastral work was done in the North-Western Provinces, Central Provinces, Bengal, Burma, and Assam, and at the same time some valuable forest surveys were executed in Burma and Bombay. The Government of India is glad to acknowledge that in no previous year has the Department done more to prove its financial value to the State, and accords its thanks to Colonel Thuillier, and the officers who assisted him for the energetic manner in which they have given effect to the policy advocated by the Government of carrying out survey operations in co-operation with the Revenue authorities on the system which has been found most conducive to the financial interests of the State. The labours of Colonel Barron, Major Sandeman, Colonel Steel, and Mr. Scott in the field of revenue survey, and the cordial assistance which they have, under Colonel Sconce, rendered in placing Cadastral surveys on an economical basis, are especially deserving of acknowledgment.

39. The Department has at the same time sustained its reputation in the field of geographical survey, and the Government of India cordially confirms the remarks of the Surveyor General on the exceptionally valuable services performed by Major Holdich, Captains Gore and Talbot on the Boundary Commission, and by Colonel Woodthorpe.

40. The Government of India regrets that the strain which has been thrown on the Department, partly by financial pressure and partly, as pointed out by the Surveyor General in paragraph 35 of the Report, by the demands made for officers to accompany political and military expeditions, has been so exceptionally severe. It is trusted, however, that by the gradual contraction of the Topographical programme, such as has been effected by the postponement of the Deccan surveys, some relief may be afforded, although it must be acknowledged that the present expansion of the Cadastral and Military programmes justifies serious consideration of the danger suggested by the Surveyor General that the Department may not be able to meet all the demands made upon it. In the meantime, His Excellency in Council desires that his high appreciation of the loyal manner in which the Department has answered to every call for its services may be placed on record.

ORDER.—Ordered, that the above Resolution be forwarded to the Local Governments and Administrations named in the margin, and to the Surveyor General of India, and to the Foreign and Military Departments for information.

Madras.	Central Provinces.
Bombay.	Burma.
Bengal.	Assam.
N.-W. P. & Oudh.	Coorg.
Punjab.	

Ordered also, that it be published in the *Gazette of India*.

(True Extract.)

E. C. BUCK,

Secy. to the Government of India.

HER MAJESTY THE QUEEN & EMPRESS OF INDIA.

From a wax Medallion by Signor C. Moscatti, Assistant Engraver,
H. M's. Mint. Calcutta.

Photo-etching - Survey of India Offices, Calcutta. October 1887.

GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1886-87.

PREPARED UNDER THE DIRECTION OF

COLONEL H. R. THUILLIER, R.E.,

SURVEYOR GENERAL OF INDIA.

CALCUTTA:
PRINTED BY THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1888.

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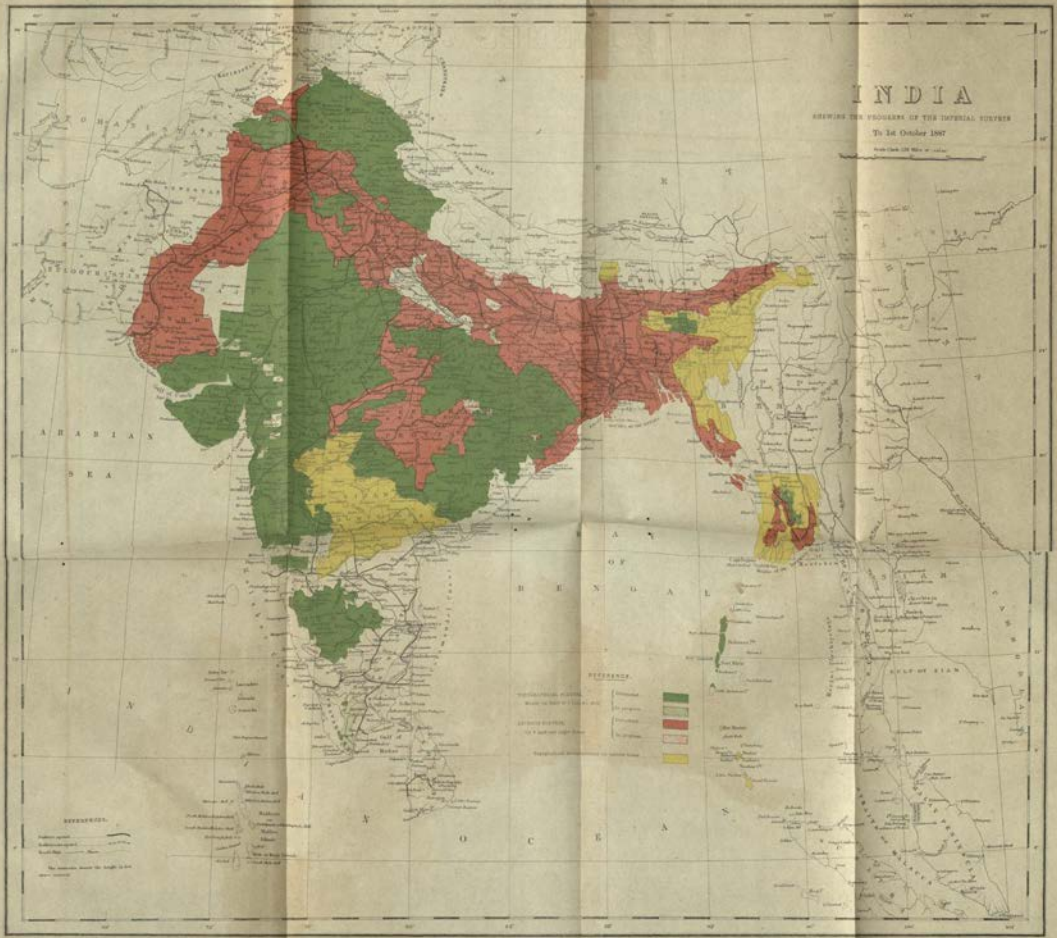

Published under the direction of Colonel H. H. Godwin, R.E., Surveyor General of India,
Survey of India Office, Calcutta, March 1888.

BAY OF BENGAL
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TO THE
GREAT TRIGONOMETRICAL SURVEY
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CEYLON
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GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1886-87.

PART I.

INTRODUCTORY.

The operations of the Department that are now reported on are for the year ending 30th September 1887.

2. The administration of the Department and the superintendence of the Topographical Branch have continued in the hands of Colonel H. R. Thuillier, R.E., throughout the year, and he was confirmed in the post of Surveyor General from the 19th February 1887, *vice* Colonel G. C. DePrée, deceased. The direct supervision of the Revenue Branch and of the Trigonometrical Branch have been carried out as before by Colonel J. Sconce, S.C., and Colonel C. T. Haig, R.E., respectively; and the latter officer was confirmed in the post of Deputy Surveyor General from 19th February 1887. The only change in the superintendence of the cartographic offices at the Head Quarters has been owing to the departure on furlough of Lieutenant-Colonel Beavan, S.C., in June 1887, when Major Baird, R.E., was appointed temporarily as Assistant Surveyor General and retained the post for the remainder of the year.

3. Hitherto the Survey parties have been distinguished chiefly by geographical designations taken from the name of the district or locality in which each party was employed; the nomenclature had therefore frequently to be changed. As this system was found to be inconvenient and confusing, the parties now have all been serially numbered and each party is known by its number, which will be permanently retained. The identity of a party can thus be readily traced wherever it may be employed.

4. The operations which have been carried out during the year under review are shown below: the arrangement of the parties in this list has necessarily been made to conform to the nature of the operations in which they were employed and therefore they do not appear in serial order:—

Statement of Field Parties and Survey Operations.

Number of Party.	Nature and *locale* of Operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Trigonometrical Survey.				
24	Coast, Madras . .	11	Mr. E. C. Ryall . . .	.....	D. S. G. Trig.
	Topographical Surveys.				
10	South Maratha Country	12	Lieutenant W. H. Pollen, R.E. Mr. A. M. Lawson . .	2″=1 mile for reduction to half scale, and 8″=1 mile, skeleton forest survey.	Ditto Rev.

Statement of Field Parties and Survey Operations—continued.

Number of Party.	Nature and *locale* of Operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
14	Mirzapur	14	Mr. W. H. Patterson	2″=1 mile for reproduction and reduction to *half* scale, and 16″=1 mile (skeleton plots).	D. S. G. Trig.
15	Baluchistan	15	Captain F. B. Longe, R.E.	½″=1 mile for reproduction.	Ditto Topo.
16	Ditto	17	Captain R. A. Wahab, R.E.	6″=1 mile, 2″=1 „, ½″=1 „ for reproduction.	Ditto ditto.
17	Gujarát and Thana	19	Colonel A. Pullan, S.C.	2″=1 mile for reduction to half scale, and 8″=1 mile, forest survey, for reproduction.	Ditto ditto.
18	Himalayas	21	Colonel H. C. B. Tanner, Bo. S.C.	4″=1 mile for reproduction and reduction to half scale, 2″=1 mile for reproduction.	Ditto Trig.
19	Madura and Tinnevelly	22	Colonel W. F. Badgley, S.C.	1″=1 mile for reproduction.	Ditto Topo.
21	Nicobar Islands	24	Lieutenant-Colonel G. Strahan, R.E.	4″=1 mile, ½″=1 „ for reproduction.	Ditto Trig.
	Forest Surveys.				
20	Lower Burma	27	Mr. H. Hörst	4″=1 mile for reproduction.	Ditto Topo.
	Cadastral Surveys.				
2	Bilaspur and Raipur	29	Mr. G. B. Scott	16″=1 mile for reproduction.	Ditto Rev.
4	Basti	32	Lieutenant-Colonel S. H. Cowan, S.C.	Ditto	Ditto ditto.
5	Gorakhpur	34	Lieutenant-Colonel J. E. Sandeman, S.C.	Ditto	Ditto ditto.
6	Darrang and Nowgong	39	Mr. E. C. Barrett	Ditto	Ditto ditto.
7	Akyab, Bassein and Thongwa.	41	Lieutenant-Colonel H. S. Hutchinson, S.C.	16″=1 mile and 2″=1 mile for reproduction.	Ditto ditto.
8	Bengal and Orissa	44	Lieutenant-Colonel W. Barron, S.C. Mr. F. W. Kelly	16″=1 mile for reproduction, and 50 feet = 1 inch, city survey.	Ditto ditto.
	Traverse Surveys.				
1	Punjab	49	Colonel E. Coddington, S.C.	2″=1 mile, compilation for reduction to half scale.	Ditto ditto.
3	Raipur	52	Colonel W. H. Wilkins, S.C.	16″=1 mile (skeleton plots).	Ditto ditto.
9	Jubbulpore and Damoh	53	Mr. G. H. Cooke	Ditto	Ditto ditto.
11	Seoni and Chhindwára	54	Lieutenant-Colonel D. C. Andrew.	Ditto	Ditto ditto.
12	Saugor and Narsinghpur	55	Mr. E. J. Jackson	Ditto	Ditto ditto.
13	Sambalpur	57	Mr. A. D'Souza	Ditto	Ditto ditto.
	Geodetic.				
22	Central India	58	Lieutenant S. G. Burrard, R.E.	.....	Ditto Trig.
23	Ditto	*ib.*	Ditto	.....	Ditto ditto.
	Tidal and Levelling Operations.				
25	India	62	Major J. Hill, R.E.	.....	Ditto ditto.

Statement of Field Parties and Survey Operations—concluded.

Number of Party.	Nature and *locale* of Operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Geographical Surveys.				
Det.	Upper Burma . .	65	Bt. Major J. R. Hobday, S.C.	4″=1 mile . .	D. S. G. Topo.
Det.	Ditto . .	67	Colonel R. G. Woodthorpe, C.B., R.E.	4″ and 4″=1 mile . .	Ditto ditto.
	Trans-Himalayan Explorations.				
	Bhutan and Tibet .	68	R. N. and K. P. . . .	.....	Ditto Trig.

These operations are described in detail in Part II of this Report, in the order in which they are given above, and the following is a summary thereof.

TRIGONOMETRICAL SURVEYS.

5. These operations have been confined, as in the previous year, to one small party, which was employed on secondary triangulation along the Madras coast. The triangulation has been extended 170 miles in length, *viz.* from Madras northwards to a distance of 45 miles beyond Nellore. A gap of about 80 miles has been left between this point and that where the previous season's operations, which were carried southwards from Cocanada, closed near Masulipatam, which could not be completed owing to the prevalence of bad weather and to sickness during the latter part of the season. It is expected that this portion will be completed during the current season and the series carried southwards from Madras as far as Point Calimere. The object of this triangulation is to furnish points as a basis for the future operations of the Marine Survey Department, and is part of a general scheme to complete the triangulation of the parts of the coasts of India and Burma where the principal triangulation has not been carried.

TOPOGRAPHICAL SURVEYS.

6. To meet the demands for remunerative surveys in the Central Provinces, it was found necessary to still further contract the topographical programme during the year under report. During the preceding year, ten parties had been employed exclusively on this class of operations, and they yielded an aggregate out-turn of 19,162 square miles of topography on various scales of survey. The Cutch Party which had completed its work in that province, and the party employed on the Deccan surveys which have had to be postponed, were diverted to Revenue operations. Thus, excluding No. 20 Party, the operations of which are confined to forest surveys in Lower Burma, the topographical parties have been reduced to eight in number, and in two of these half the establishments have been employed on special surveys for the Forest Department in the Bombay Presidency. On the other hand, a topographical section was added to the cadastral party employed in the Akyab district, Burma, so as to complete the topography of some parts of the hill ranges situated between the valleys to which the cadastral survey had been restricted. In the Punjab, the party engaged in compiling topographical maps from the village maps of the settlement surveys has made original surveys of small detached portions of Native States, intermingled with British districts, but for the larger portions of the Native States, the topography of the old maps, though admitted to be imperfect, has been accepted for the new compilations, an extensive re-survey at the present time being considered to be inadvisable.

7. Out of the eight topographical parties, five have been employed in continuation of the preceding year's work: *viz.*, two in the Bombay Presidency, one in Gujarát, another in the Southern Marátha Country (with half their establishments only); one in Baluchistan, which is at the disposal of the Military Department; one in the Mirzapur district, and one in the Himalayas.

8. Of the remaining parties, one which had hitherto been employed in Rajputana was withdrawn therefrom, and the survey thereof postponed in order to make a second party available for the Military programme. This party was transferred to Baluchistan and has been engaged chiefly on special surveys on the frontier required by the Military authorities, but it has also added to the extension of the general survey of Baluchistan in conjunction with the party previously engaged thereon. The completion of the survey of the Mysore State during the preceding year rendered a party available for new work, and the Government of Madras having accepted the proposal of the Government of India for the transfer of the topographical work remaining to be completed in that Presidency from the local Survey Department to the Imperial Department, this party was selected on account of its local experience to undertake the operations in Madras, and it has been employed thereon in the districts of Madura and Tinnevelly. The work, however, has been necessarily almost confined during this first season to triangulation, and but little has been added to the general out-turn of topography. The eighth party has been engaged, in continuation of the survey of the Andaman Islands, in making a survey of the Nicobar Islands, the main object of which was to meet the requirements of navigation. The coasts have been accurately surveyed and as much topographical detail in the interiors of the islands secured as the limited time available permitted, as it was considered desirable to restrict the operations to one season.

9. The aggregate results of the topographical surveys during the year amount to 17,510 square miles, which is exclusive of forest surveys and of the standard mapping in the Punjab, compiled from the village maps of the settlement surveys. The out-turn is composed as follows:—

11,786	square miles	surveyed on the	½-inch	scale.
257	,,	,, ,,	1-inch	,,
5,041	,,	,, ,,	2-inch	,,
354	,,	,, ,,	4-inch	,,
72	,,	,, ,,	6-inch	,,

FOREST SURVEYS.

10. The special skeleton survey of forest boundaries in the Belgaum district has been continued and completed for the forest tract to which the operations were required to be extended. The maps are on the 8-inch scale and show boundaries only, except in a few cases where large streams or made roads pass through the tract. For general purposes, the topography of the tract will be surveyed on the 2-inch scale in the course of the topographical operations in the Southern Maratha Country; and for forest requirements, the Forest Officers will add such topography to the 8-inch skeleton maps as they may consider to be necessary. The above procedure applies to the forests in the Southern Circle of the Bombay Presidency.

In the Northern Circle, however, more elaborate operations have been demanded by the Bombay Government. Here a complete survey in full detail on the 8-inch scale is required of such of the forest reserves where surveys do not exist on the 4-inch scale, and a commencement has been made in the forests of the Thána district. Two half parties have been employed on these forest surveys in the Bombay Presidency.

11. Two small forests in the Gorakhpur district have been surveyed on the 8-inch scale by the cadastral survey party working in that district.

12. The survey of the forests in Lower Burma has been continued on the 4-inch scale by No. 20 Party; but, owing to the unsettled state of the country and the impossibility of providing police guards for all the scattered detachments in the Prome district, the Native section of the party employed there became quite demoralized, and it was found necessary to suspend the work in Prome and to remove the detachment therefrom. The operations, therefore, had to be confined to new ground in the Pegu district in which preliminary triangulation and traversing constituted the chief work of the party, and the out-turn of final survey has thus been very small. The failure here, however, enabled the party employed in Upper Burma to be materially strengthened by the withdrawals from Prome, and thus a considerable increase in the out-turn of new

geography has been obtained. The areas of the forest surveys above referred to are as follows:—

296 square miles surveyed on the 8-inch scale.
46 „ „ 4-inch „

CADASTRAL SURVEYS.

13. Six parties have been engaged on cadastral surveys during the year. Of these, the operations of five parties have been continued with little change from those on which they were engaged during the previous season: (1) The party employed in Basti has extended its work northward, exclusively in its own district; and the only thing to be specially mentioned in connection with the work of this party is the very minute sub-division of property that has been met with, the average size of the separate plots in which the cultivators have occupancy rights being 0·27 of an acre, which is quite unprecedented for smallness, and is about one-third of the average size of the cultivators' plots in the adjoining district of Gorakhpur. Close upon two million plots have been surveyed, areas calculated, and rights recorded in Basti, while in Gorakhpur, in a considerably larger area the number is less than one million. (2) The party engaged in Gorakhpur has been specially strengthened for the purpose of its accomplishing a larger out-turn, so that the remaining area of the district may be completed in two seasons, that is, before November 1888, as required under the conditions of the expiring settlement. The out-turn has thus been raised to 1,048 square miles, being 228 square miles more than was surveyed last year. This party has also sent a detachment to resume cadastral survey operations in the Tarai district for certain selected villages where the extension of cultivation has rendered such operations advisable. A new departure has been taken in the cadastral work of this detachment by the employment of the village *patwáris* as surveyors in place of professional *amins*, and although some difficulty was at first experienced in training the men, the plan eventually proved quite successful and excellent work was obtained. (3) In Assam, the party having completed the area required to be cadastrally surveyed in the Kámrúp district, has moved into district Darrang, where it has finished the entire area set apart for cadastral survey, the operations being confined, as in Kámrúp, to the villages in which the cultivation is permanent, that is, where the same lands are cultivated year by year, in contradistinction to the villages where the cultivated lands are changed after successive periods. (4) In Burma, the party has been employed partly in the Akyab district, where the area for cadastral survey has been completed, and partly in the Bassein district, in which several circles which had been omitted from the cadastral survey of 1879—83 have now been assigned for survey. The Thongwa district, which adjoins Bassein, has also been assigned to this party for cadastral survey, and preliminary traversing has been undertaken there. Besides completing the cadastral area remaining in Akyab, the party, having been specially strengthened with a staff of topographers, has carried out a topographical survey of parts of hill-ranges lying between the villages to which the cadastral survey was restricted, and thus has provided for the completion of several topographical sheets. (5) In the Central Provinces, the party which had hitherto been employed in the Bilaspur district could not be wholly re-employed therein on account of a partial famine through failure of the autumn crop of 1886, and one section was diverted to the adjoining district of Raipur, where a tract intended for settlement survey by *patwáris* was assigned to it. The total area surveyed in the two districts is 1,022 square miles, showing an increase of 259 square miles on the out-turn of the previous season, and the cost-rate has been reduced from R169-11 to R132-14 per square mile.

14. The last of the six parties which had been employed on cadastral surveys during the previous year is the party which had carried out experimental operations in District Mozufferpore of Bengal, and which, on the stoppage of the Mozufferpore survey, was available for transfer elsewhere. Any large operation sufficient for the employment of the whole party in one locality was not forthcoming, and three separate operations have been assigned, each suitable for a section representing a third of the party.

(*a*) The first section was sent to Calcutta for the survey of the town, the operations of which will be referred to hereafter.

(*b*) The second section was despatched to the Dinagepore district for the cadastral survey of the Sankarpur Estate at present under the Court of Wards. The survey of this estate has presented unusual difficulties on account of the lands composing it being much scattered; not only are many villages in which the estate is exclusively interested detached singly, but in villages in which the estate is only partially interested the lands are found lying in single fields or in groups of fields with the lands of other estates intermingled with them.

(*c*) The third section was despatched to Orissa for the cadastral survey of the Government Estate of Angul, formerly a Tributary State, which was confiscated in 1847, and which is now for the first time being brought under survey for settlement purposes. The main part of the work which has been effected has been village boundary traversing, but an area of 61 square miles has also been surveyed cadastrally, and some of the *sarbarákárs* (village headmen) have been trained for cadastral survey work to be undertaken next season.

The areas surveyed cadastrally are—

	Square miles.
North-West Provinces	1,898
Assam	547
Burma	546
Central Provinces	1,022
Bengal	260
TOTAL	4,273

TOWN SURVEY.

15. The survey of Calcutta has been undertaken in accordance with the representation of the Municipal Commissioners to the Government of Bengal, that the maps of the survey of 1847—49 had become out of date on account of the numerous changes that had occurred, and, moreover, that the maps had been drawn on too small a scale to show the details of the town with sufficient accuracy. The present survey is being effected on the scale of 50 feet to an inch, which is double the scale of the former survey, and all details are being represented with every possible minuteness. Besides the ordinary particulars concerning streets and houses, the boundaries of the separate properties which pay revenue to Government are being shown, and information is being collected to enable a new Register of properties to be prepared for the Calcutta Collectorate, if found to be necessary.

TRAVERSE SURVEYS.

16. The party employed in the Punjab has continued the same operations in British districts as formerly, its field work mainly consisting of the construction of a traverse framework on which topographical maps are drawn in office by reduction from the village maps of the settlement surveys. Besides this, during the present season, small outlying portions of the territories of the Sikh States have been surveyed, so as to render the topographical maps complete, and where extensive tracts of these States have been met with, the survey of which forms no part of the programme of the present operations, the portions of the old maps of the States, surveyed in 1847—50, have been redrawn so that the new series of standard-sized sheets may be published without blanks.

17. The traverse surveys of the Central Provinces, designed to furnish a skeleton basis for settlement surveys by village *patwáris*, have been continued in the districts of Raipur, Sambalpur, Jubbulpore and Damoh where the operations had been begun during the previous season, and Districts Sambalpur and Damoh have been completed. Four other districts, *viz.* Saugor, Narsinghpur, Seoni and Chhindwára, have been entered upon during the season by two new parties, which have been brought up from the Bombay Presidency, where they had been employed on topographical surveys. In the traverse surveys in the Central Provinces, there is besides the village boundary traverses, a complete system of interior sub-traverses, so as to furnish conveniently-sized blocks, for the surveys of the fields by *patwáris*, and every theodolite station is marked with a substantial stone.

The areas which have been traversed are—

	Square miles.
Punjab	6,085
Central Provinces	10,576
TOTAL	16,661

SPECIAL OPERATIONS.

18. As only one officer could be spared for astronomical work, the telegraphic longitude operations were suspended, and latitude observations resumed. These have been extended south of Jubbulpore on the meridian of 80,° in continuation of the operations of 1884-85, and observations have been completed at five stations. The operations were brought to a close somewhat early, in order to carry out a further series of experiments with the two transit instruments at Dehra Dún for the purpose of elucidating the curious anomalies in the result obtained with those instruments in the determination of differential longitudes which were referred to in the Report for 1885-86.

19. The tidal operations have been continued as usual. Observations for registration of tides were taken at 17 ports in India, Burma, the Andamans, Ceylon and Aden. One new observatory has been established, while that at Dublat was swept away by the cyclone of 29th September 1886, but fortunately not until the 5 years' registration had been completed.

GEOGRAPHICAL SURVEYS AND EXPLORATIONS.

20. In addition to the regular operations of the topographical parties, two detachments, one under Captain (now Major) Hobday, which was raised to the strength of an ordinary field party, and another under Colonel Woodthorpe, R.E., have been employed on geographical surveys in Upper Burma, and considerable additions have thus been made to our imperfect knowledge of that province. The various military expeditions for pacifying the country have afforded the means of obtaining this additional geographical information, and every opportunity, as far as the strength of the establishment permitted, has been availed of to send surveyors with the various columns to acquire new geography. The area that has been thus reconnoitred amounts to 15,284 square miles, chiefly on the $\frac{1}{4}$-inch scale, and the work is all based on triangulation. Besides this, various reconnaissances executed by military officers and soldiers attached to the force, have been utilised and incorporated into the maps issued by this Department, so that every means of adding to our knowledge of the geography of the country has been taken advantage of. To Major Hobday, who has been engaged on these operations since the first occupation of Upper Burma, the successful work that has been accomplished is mainly due; and it is also by his efforts, in conjunction with Captain Dun, Deputy Assistant Quarter Master General, that the satisfactory results of the association of the Survey Department with the Intelligence Branch of the Quarter Master General's Department have been obtained. His Excellency the Commander-in-Chief has been pleased to express his approval of Major Hobday's services, and of those serving under him. Colonel Woodthorpe accompanied the force that proceeded from Manipur into the Chindwin Valley, and has furnished, in conjunction with Mr. Ogle, his assistant in this as well as in previous explorations on the Assam frontier, a valuable addition to our maps. He succeeded also in carrying the triangulation from Manipur, which is in connection with the main triangulation of India, to the neighbourhood of Mandalay, and effected a junction with that executed by Major Hobday, which was previously unconnected. It will be remembered that Colonel Woodthorpe has been engaged from the field season of 1884-85 on incessant exploration work;—firstly, to the Bor Khámpti country, in the valley of the western branch of the Irrawaddy, on return from which, after much exposure and hardship, he was selected to accompany the Gilgit Mission. He had no sooner returned from this arduous expedition than he volunteered for this service in Burma. It is gratifying to record that the services of this officer have been recognized by the award of the Companionship of the Military Order of the Bath.

21. Of Trans-Himalayan work the report of the explorations in Nepal and Tibet by M—H, which was mentioned at page 54 of the Annual Report

for 1885-86, has been separately published, with a sketch map illustrating his routes. The detailed report of explorer R. N.'s work in Eastern Tibet is still incomplete, but a summary thereof by Colonel Tanner will be found in the appendix, accompanied by a sketch map of Bhutan, which embodies all the information available up to date regarding that country.

22. In 1880, a native of Sikhim, K. P., was sent in company with a Chinese *láma*, by the late Captain Harman, to Tibet for the purpose of exploring the course of the Sangpo river below Gyala Sindong, the point which had been reached by explorer G. M. N., to the plains of India; or, failing this, to throw marked logs of timber into the stream at the lowest point reached, in order to solve the question of its identity with the Dihang. K. P. has returned to India after many adventures and has given a narrative of his travels, which shows that, owing to the delinquency of the *láma*, the arrangement for casting logs into the Sangpo was not carried out. K. P. was sold as a slave in the Pemakoi country, from which he eventually managed to escape. He succeeded in penetrating to a place called Onlet, on the Sangpo, which he states is not much more than 40 miles from the plains of India; and his account, combined with information derived from a Mongolian *láma*, who had lived for many years near Gyala Sindong, has enabled Colonel Tanner to construct an amended chart of the course of the Sangpo between Gyala Sindong and the point to which our knowledge of the Dihang river extended, which will be found in the appendix. It is intended to publish the itineraries of both K. P. and R. N., together with the information obtained from the *lámas* in a separate report. Meanwhile, a short account is given in Part II, and in Colonel Tanner's note in the appendix, which also contains a résumé of the work done up to date, both in Bhutan and on the Lower Sangpo.

HEAD-QUARTERS OFFICES.

23. The account of the work done in the various offices at the head quarters is given in Part III of this Report. The number of maps published during the year, including new editions of old maps, amounted to 315. This is exclusive of cadastral maps, of which 3,843 have been published. The total number of maps issued amounted to 178,398, valued at R1,36,344. The income from map sales amounted to R9,254.

24. The vast amount of mapping that has been thrown on the drawing offices by the surveys and reconnaissances executed by the officers attached to the Afghan Boundary Commission has caused great pressure on these sections. Considerable progress has been made in the completion of these maps without interference with the ordinary work, which was further increased by the urgent demands for maps of Burma and Baluchistan In the Lithographic Office a series of statistical maps has been commenced, showing the area percentage of the principal crops grown in different districts throughout India. The Military and Railway map, which was noticed in last year's Report, has made steady progress. This map is in 12 sheets and will be printed in four colours. It is hoped that it will be ready for publication during the current year. Among the maps published by the photo-zincographic process may be mentioned a preliminary map of Upper Burma on the 16-mile scale, compiled from the sheets on the $\frac{1}{4}$-inch scale, which were prepared by Major Hobday from all available sources. These maps are necessarily very imperfect, as the acquisition of geographical information in Upper Burma and its accuracy must for some years be gradual and progressive. It is hoped that new editions of the above maps, giving further details, will shortly be published.

25. The processes of heliogravure have made great progress during the year: two quarter-sheets of the Atlas of India have been engraved directly by the aid of photography from manuscript drawings. The results that have been obtained show that for the reproduction of line work the process is well adapted to take the place of hand engraving for temporary purposes, such as for maps in which the geographical information is imperfect and which are likely to be superseded by more reliable materials. For the reproduction of maps, however, in half tone, the process requires further development. The heliogravure processes have also been utilised largely for the reproduction of drawings for the Archæological Survey, in which some beautiful specimens have been produced, and for a Technical Art Series for educational purposes. A medallion portrait of

Her Majesty the Queen-Empress of India, reproduced by the photo-etching process, is appended as a frontispiece. The use of electrotyping for duplicating engraved copper-plates has also been largely extended during the year. The collotype process has also made some advance and specimens of reproduction of a water-colour drawing, printed by this process, will be found in the appendix. These specimens also illustrate the advantages of orthochromatic photography to which some attention has been devoted.

ESTABLISHMENT.

26. During the year the Department has sustained the loss of the services of two officers who have been associated with it for many years. First, by the lamented death of Colonel G. C. DePrée, S.C., late Surveyor General of India. In February 1886, Colonel DePrée was forced by illness to take furlough to Europe, with the intention of returning to complete his full period of service. His health, however, prevented him from carrying out his desire, in which he was actuated solely by loyal motives and by his devotion to the department. Deriving no benefit from his residence in England, Colonel DePrée went to Jersey, where he died on the 18th February 1887, a few months before he would have had to retire from the Department, under the superannuation rules. He had spent 36 years in the service of the Indian Government, of which over 32 years had been passed in the Survey Department. In January 1883, after 28 years' service in executive duties of the Topographical Branch, Colonel DePrée was appointed Deputy Surveyor General in charge of Topographical Surveys, on the occasion of the separation of the duties of that office from those of the Surveyor General; and, subsequently, on the retirement of General J. T. Walker, C.B., R.E., he became Surveyor General of India. Lieutenant-Colonel T. T. Carter, R.E., Deputy Superintendent, 1st grade, retired on the 9th January 1887, owing to ill health, after a service of 29 years under the Indian Government, of which nearly 25 years had been spent in the Trigonometrical and Topographical Branches of the Survey Department.

27. The resources of the Department have been severely taxed in providing officers to superintend the various field operations and in meeting all the demands that have been made upon it. The existing strength of the Senior Division is unquestionably insufficient to continue to bear the strain under which the Department has been working during the past three years. The contraction of the Topographical programme, which is a matter of much regret in view of the completion of the entire first survey of India and of the pressing need of surveys in Upper Burma, has afforded no relief, as the parties employed thereon have been merely diverted to other work to meet the demands for re-settlements. The trained agency available is so limited as to cause much anxiety for the efficient execution of the surveys now in progress; this is due partly to appointments to fill existing vacancies having been withheld, partly to the expansion of the military programme, and to the extra demands that are now made for officers to accompany military and political expeditions. It is essential therefore for the proper prosecution of the work that may be required from the Department, and for the due administration thereof, that a fixed programme should be decided on for a series of years, and that the establishments should be maintained at an adequate strength.

28. It is gratifying to record that the labours of the officers of the Survey Department in Afghanistan and Upper Burma have been appreciated and rewarded.

In recognition of services with the Afghan Boundary Commission, Lieutenant-Colonel Holdich, Majors Gore and the Hon'ble M. G. Talbot have each received a step of brevet rank; Sub-Surveyors Yusuf Sharif and Imam Sharif have obtained the personal distinction of Khan Bahadur and Sub-Surveyor Hira Sing that of Rai Bahadur. Colonel Holdich has further been awarded the Founder's medal of the Royal Geographical Society in London for the services he has rendered to geographical science.

In recognition of their services in Burma, Colonel Woodthorpe, R.E., has been appointed to be a Companion of the Order of the Bath and Major Hobday has received a step of brevet rank.

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

TRIGONOMETRICAL SURVEYS.

COAST TRIANGULATION.

CHINGLEPUT AND NELLORE DISTRICTS, MADRAS.

No. 24 Party.

29. These operations were continued during the season under the executive charge of Mr. Ryall, their object being to fix points of reference for the Marine Survey, at intervals of from 5 to 15 miles along the east coast of India. Light-houses and other permanent marks are utilized for the purpose where such are available, and in their absence beacons are constructed in conspicuous places, their positions being fixed by triangulation or traverse.

Personnel.
Mr. E. C. Ryall, Officiating Deputy Superintendent, 4th grade, in charge.
Mr. J. Bond, Surveyor, 4th grade.

30. The party left recess quarters at Mussooree on the 25th November and proceeding to Masulipatam where the stores and instruments had been deposited, went thence by Buckingham Canal to Madras. Owing to the protraction of the north-east monsoon, work could not be commenced until the 26th December and then much delay was caused by the illness of both Messrs. Ryall and Bond. The observations were further retarded by delay in obtaining the sanction of the Conservator of Forests for felling trees for the purpose of clearing the rays between stations required to fix the Ennur beacon.

31. The triangulation this season was arranged in three separate sections, each originating from sides of the principal triangulation of the Madras Coast Series :—

(1) A series of 22 triangles, from St. Thomas' Mount to Ennur, over a direct distance of 22 miles.
(2) From Armugham light-house, Oudali H. S., and Narsimkonda h. s. to the coast, comprising 17 triangles, in length 45 miles.
(3) From Narsimkonda h. s. and Kistama H. S. to Ramapatnam, 41 triangles, in length 61 miles.

In all, the triangulation was extended over 170 miles of coast line northward from Madras, by which nine beacons and other points on the coast were fixed in addition to three light-houses.

32. Two traverses $7\frac{1}{2}$ and 4 miles in length respectively, were also run from stations of the main series to fix beacons and marks which could not be advantageously connected by triangulation.

33. A distance of about 80 miles of coast line remains between the most northern point reached this season and the most southern point of the last season's work; this interval will be completed during the next season. During the recess all computations and charts of the season's work were completed and brought up to date.*

*Mr. Ryall speaks favourably of Mr. Bond's work and his endeavours to make up for the time lost through sickness.

TOPOGRAPHICAL SURVEYS.

SOUTH MARATHA COUNTRY, BOMBAY PRESIDENCY.

No. 10 Party.

34. This party, which during the previous season had been under the charge of Lieutenant F. B. Longe, was at the beginning of the field season, on the transfer of Lieutenant Longe to a party in Baluchistan, placed under the charge of Lieutenant W. H. Pollen, who supervised the operations in the field, and who on the return of the party to its recess station, when he was about to proceed on leave to Europe, was relieved of the charge by Mr. A. M. Lawson.

Personnel.

Lieutenant-Colonel T. T. Carter, R.E., Deputy Superintendent, 1st grade, in charge from 9th to 31st December 1886.
Lieutenant F. B. Longe, R.E., Officiating Deputy Superintendent, 4th grade, in charge up to 19th October 1886.
Lieutenant W. H. Pollen, R.E., Officiating Deputy Superintendent, 4th grade, in charge from 20th October to 8th December 1886, and from 1st January to 6th June 1887.
Mr. A. M. Lawson, Surveyor, 2nd grade, in temporary charge from 7th June 1887.
Mr. W. M. Kelly, Assistant Surveyor, 1st grade.
Mr. R. R. Dickinson, Assistant Surveyor, 1st grade.
Mr. O. D. Smart, Assistant Surveyor, 2nd grade.
25 Sub-Surveyors and others.

Mr. Lawson held charge until 21st October 1887, on which date Lieutenant-Colonel H. S. Hutchinson, who had been appointed to the party, joined and took charge.

The short incumbency of Lieutenant-Colonel T. T. Carter, *viz.*, from 9th to 31st December, should also be mentioned, although he was unable to take any share in the field operations, having joined the party on return from furlough in bad health which soon compelled him to retire from the service.

The field season extended from 16th November 1886 to 27th May 1887.

35. The party, divided into two sections, has been employed on two distinct operations. One of these is a topographical survey on the 2-inch scale, showing village boundaries, similar to the survey which has been carried on in other parts of the Bombay Presidency; the other is a partial survey of forests on the 8-inch scale, exhibiting, according to the specification of the Forest Department, only the boundaries of the forests, and such details (where existing) as perennial streams or made-roads, all other details and the delineation of the hill features being entirely omitted. The forest survey was carried on in a tract which had not been included in the topographical survey, and the features which have been omitted will hereafter be surveyed on the 2-inch scale.

36. The topographical section has undertaken the completion of Sheet 205, which had been partially surveyed by No. 11 Party during the previous season; also, it has completed Sheet 243, which had been left undone the same season; and it has commenced and finished the topography of Sheets 305 and 306. The portions of Sheets 205 and 243 consisted of difficult mountainous country forming parts of the Western Ghâts; Sheet 305, crossed by ranges of flat-topped hills covered with thorny jungle, was also somewhat difficult for the topographers; but Sheet 306 was all open easy country. A few descriptive notes furnished by Mr. Lawson with the aid of the official gazetteer, are printed in the appendix, page ii.

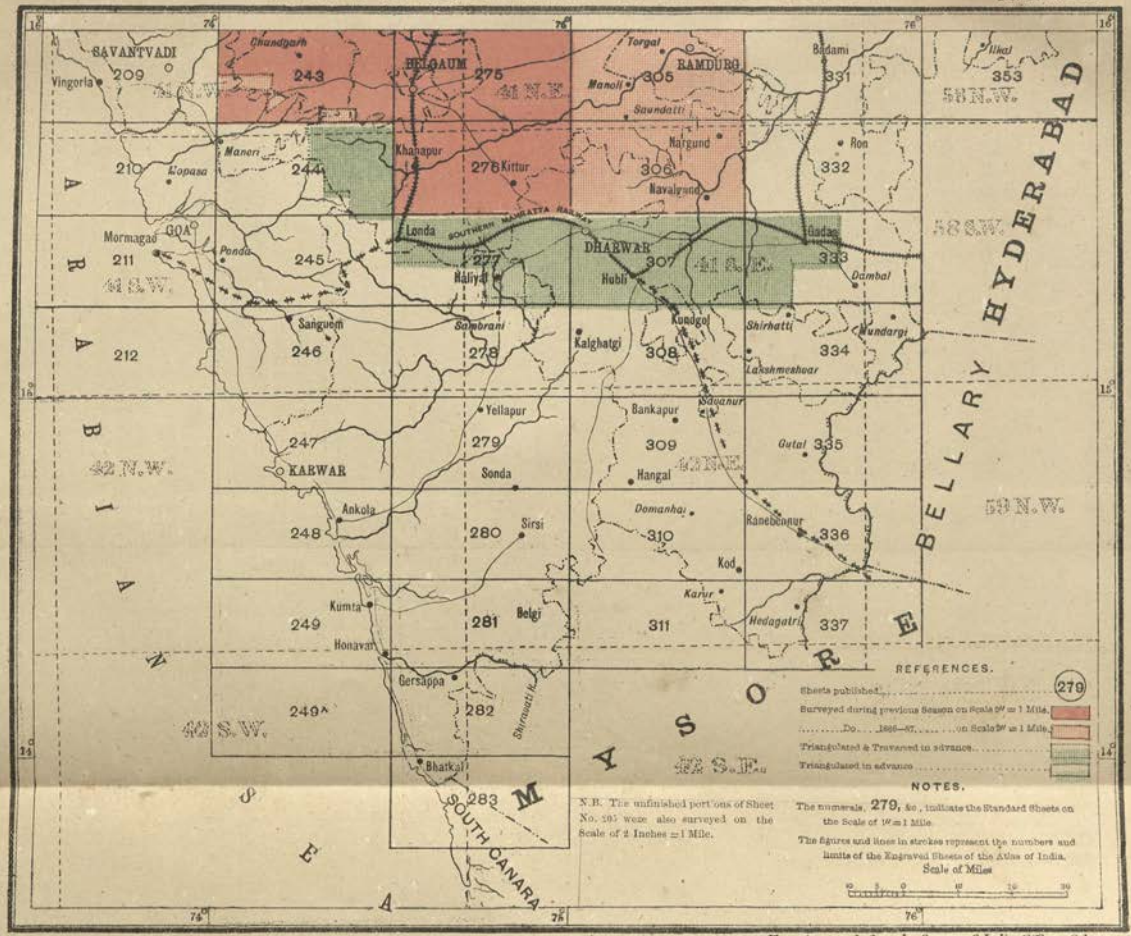
37. The areas surveyed on the 2-inch scale in the several districts and States are shown in the following statement:—

	Square miles.
Kaládgi District	39
Belgaum „	425
Dhárwár „	474
Ratnágiri „	32
Kolhápur State	206
Sángli „	13
Sávantvádi „	53
Rámdurg „	113
Torgal „	57
TOTAL	1,412

BOMBAY SURVEY.

INDEX TO THE SOUTH MARATHA TOPOGRAPHICAL SURVEY.

No. 10 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut. Colonel H. R. Thuillier, R.E., *Surveyor General of India.*

Survey of India Offices. Calcutta, October.

1887

The area triangulated is 1,570 square miles of open country, which has been accomplished by means of observations at 150 stations. The area traversed is 1,527 square miles, of which 1,300 square miles are in advance for next season's detail survey. During both operations of triangulation and traversing, the heights of 190 points have been determined.

38. The topography was surveyed as closely as the scale admits of and it has been tested by 76·5 linear miles of check lines, but these checks are not considered to be sufficient and several sections remain to be tested. Village boundaries in British districts were surveyed according to the marks found on the ground and were afterwards compared with the Revenue Survey maps. In the case of Native States, only the State boundaries have been surveyed. During the recess, the mapping of the 2-inch sections of Sheets 243, 305 and 306 has been done, but the new sections of Sheet 205 consisting of intricate hill features are still unfinished.

39. The Forest survey section has been employed in the Khánapur forests of the Belgaum district; and on account of the forest and village lands being so much intermingled, the survey has necessarily comprised the cultivated lands situated within the forests but still remaining with the villages, as well as the forest reserves which have been exscinded. As required by the Forest Department, the village unit has been upheld, the village boundaries being first surveyed and then the boundaries of the included forests, and the forest boundaries being traced from the Revenue Survey maps according to the field "numbers" which had been transferred by Gazette Notification to Forest jurisdiction. The number of villages falling within the tract that has been surveyed is 83, from 76 of which lands have been exscinded for forests, and while the total area of the tract is 215 square miles, the aggregate area of the portions reserved for forests is 154 square miles. The aggregate of the traversing of the village and forest boundaries is 862 linear miles, fixing 8,623 theodolite stations mostly on boundary stones and a few on stones specially embedded.

40. In the construction of the maps, the village unit has also been retained, separate maps having been projected for each of the villages, showing both the forest lands and the lands left for village assessment. It will be understood from what has already been mentioned regarding the nature of the survey applied for by the Forest Department, that the maps, which are on the 8-inch scale, are mere skeletons showing the boundaries to which in some cases surveys of large streams or made-roads have been added where existing, but there has been no representation of the hill features or of the minor drainage. Copies of the maps have been drawn for the use of the Forest Department.

41. The total cost of the party for twelve months ending 30th September is ₹50,843, half of which is payable by the Government of Bombay (Forest Department); and the cost-rates per square mile thus deducible are shown in the table at page 72.

42. The party suffered a good deal from fever both in the forest tracts and open country during the early part of the season, two cases proving fatal. Guinea-worm was also common all over the district.

43. The recess office of the party at Poona was inspected during September by the Deputy Surveyor General in charge of the Revenue Branch, who was satisfied with the character of the field work and with the progress made as regards the computations and drawing in office.*

* Mr. A. M. Lawson, who has prepared the annual report, reports favourably of Messrs. Kelly, Dickinson and Smart, and states that the undermentioned Sub-Surveyors have done excellent work, *viz.*, Fyzullah Khan, Damodar Gopal, Govind Janardhan, Ramrao Yadho, Vitoba Nagaji and Babaji Ram Chunder.

MIRZAPUR DISTRICT, NORTH-WESTERN PROVINCES.

No. 14 Party.

44. This party resumed field operations in the Mirzapur district on the 17th November 1886 under the superintendence of Mr. W. H. Patterson who has held charge during the entire year. Field work was continued till the end of April, when the party started for recess quarters at Mussooree.

Personnel.

Mr. W. H. Patterson, Officiating Deputy Superintendent, 4th grade, in charge.
Mr. L. J. Pocock, Surveyor, 3rd grade.
„ C. F. Hamer, „ 4th „
„ C. D. Potter, „ 4th „
„ W. J. Cornelius, Assistant Surveyor, 1st grade.
Mr. H. T. Kitchen, Assistant Surveyor, 1st grade.
Mr. E. F. Berkeley, Assistant Surveyor, 2nd grade.

Sub-Surveyors

Azim Khan, Barkat Ali,
Prem Raj, Gurdutt Sing,
and 6 others.

45. The out-turn of work consisted of (*a*) the triangulation of 525 square miles in sheets 198, 199 and 212; (*b*) the detail survey on the 2-inch scale of 454 square miles in the same sheets; (*c*) the completion of the boundary survey of seven villages in Pargana Bijaigarh left incomplete by the Revenue Survey Party previously employed in the district owing to the hilly nature of the country; (*d*) the mapping of details taken from the village plans of the Settlement Survey executed in 1864—68, and based on the traverse survey of last season of 1,223 villages in sheets 168, 169, 181 and 182, comprising an area of 391 square miles; (*e*) the traverse survey of 536 villages in Parganas Khera Mangraur and Naugarh, sheets 197 and 198, forming the Chakia Estate of the Maharaja of Benares, of which a cadastral survey will be undertaken during the present season.

46. The operations under head (*a*) complete the triangulation required for the 2-inch detailed survey in District Mirzapur; under head (*b*), the accuracy of the topography has been carefully tested by the examination of the field sections from positions *in situ* by the executive officer and the European assistants; under class (*c*) the work involved the setting up of the theodolite at 41105 stations and the measuring of 860 linear miles of chain traverse. Azimuths were observed at 13 stations to check the bearings of the traverse lines.

47. Three native soldiers were attached to the party during the field season for training, and after being instructed in the use of the plane-table they conjointly contributed an area of 57 square miles of 2-inch survey to the season's out-turn.

48. The country topographically surveyed is of the same intricate and hilly nature as that met with in previous seasons. Most of the precipitous slopes of the Kaimur range of hills fall within the season's work, and the survey of these, in addition to the intricate jungle-clad ground met with elsewhere, rendered the work difficult and laborious. Further delay was incurred by the health of the establishment which was bad during the entire season; the detachments working in the Kaimur hills were attacked with a malarious type of fever which prostrated the surveyors for a considerable time and caused serious interruptions in the work. The out-turn therefore is not so large as was anticipated and the cost-rates have thus been somewhat enhanced.

49. During the recess the following maps have been completed on the 2-inch scale:—8 sections of the standard size comprised in sheets Nos. 168, 181, 184, 185 and 200 for reproduction to scale; and 5 sections of sheets Nos. 200 and 201 for reduction to 1-inch. The fair drawing of sheets Nos. 184, 198, 199 and 212 will be completed in the Drawing Office at Calcutta.

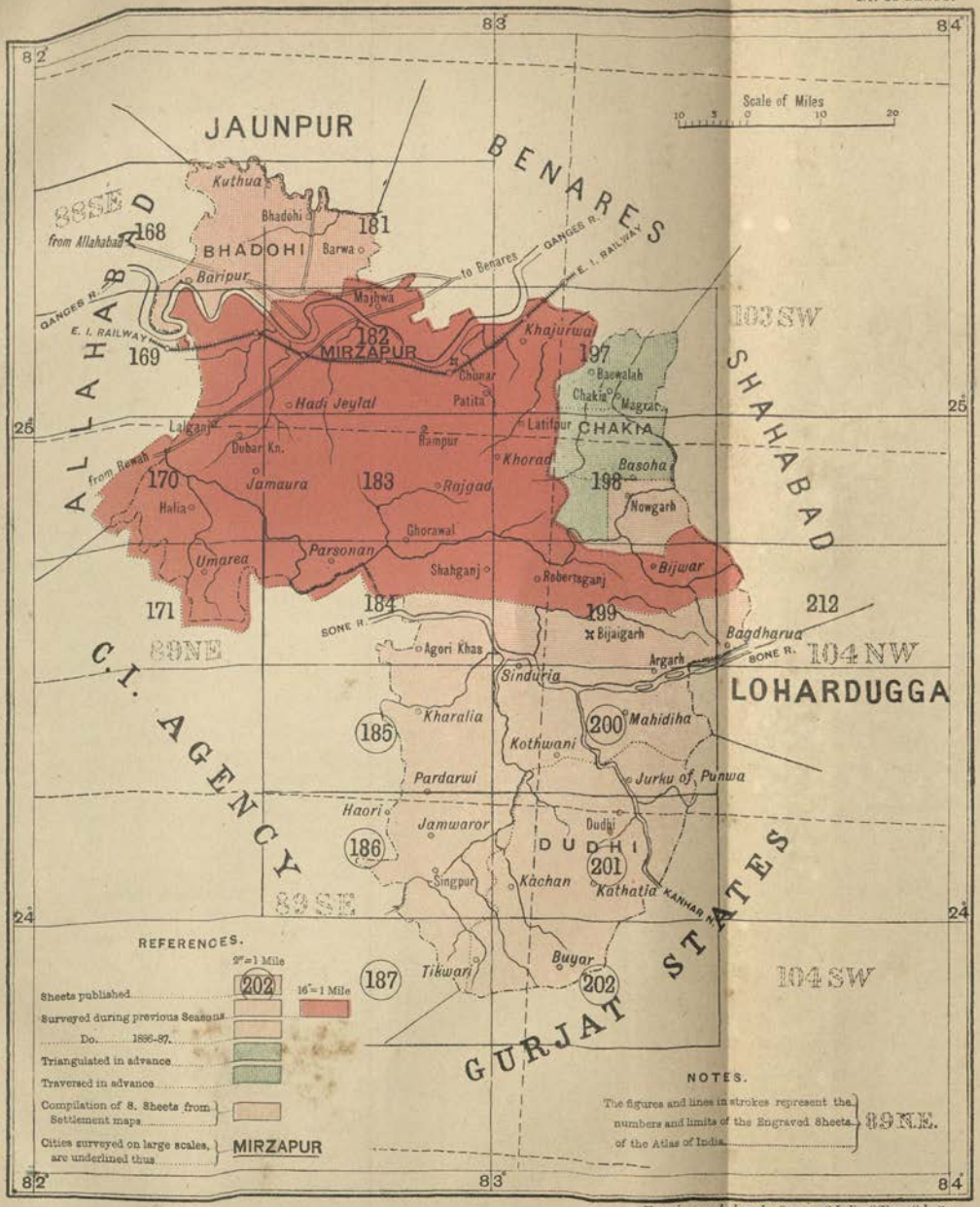
In addition to the above the plotting of the polygons of the villages in the Chakia Estate and the records connected with the traverses thereof were completed. The computations of the season's triangulation were finished and a chart of triangulation for the whole district of Mirzapur prepared on the $\frac{1}{4}$-inch scale. The arrears of the general reports and records of the Khándesh and Bombay Native States and of the Bhopal and Malwa surveys which had been entrusted to Mr. Patterson's supervision, have now been completed in the office of this party.

50. The area that now remains for survey in the Mirzapur district amounts to about 350 square miles, of which 175 square miles, comprising the Maharaja of

NORTH WEST PROVINCES SURVEY.

INDEX TO THE SURVEY OF DISTRICT MIRZAPUR.

No. 14 PARTY.



REFERENCES.

Sheets published	2"=1 Mile 202 / 16"=1 Mile
Surveyed during previous Seasons	
Do. 1886-87.	
Triangulated in advance	
Traversed in advance	
Compilation of 8. Sheets from Settlement maps	
Cities surveyed on large scales, are underlined thus	MIRZAPUR

NOTES.

The figures and lines in strokes represent the numbers and limits of the Engraved Sheets of the Atlas of India. 89NE.

Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel H. R. Thuillier, R.E., *Surveyor General of India.*

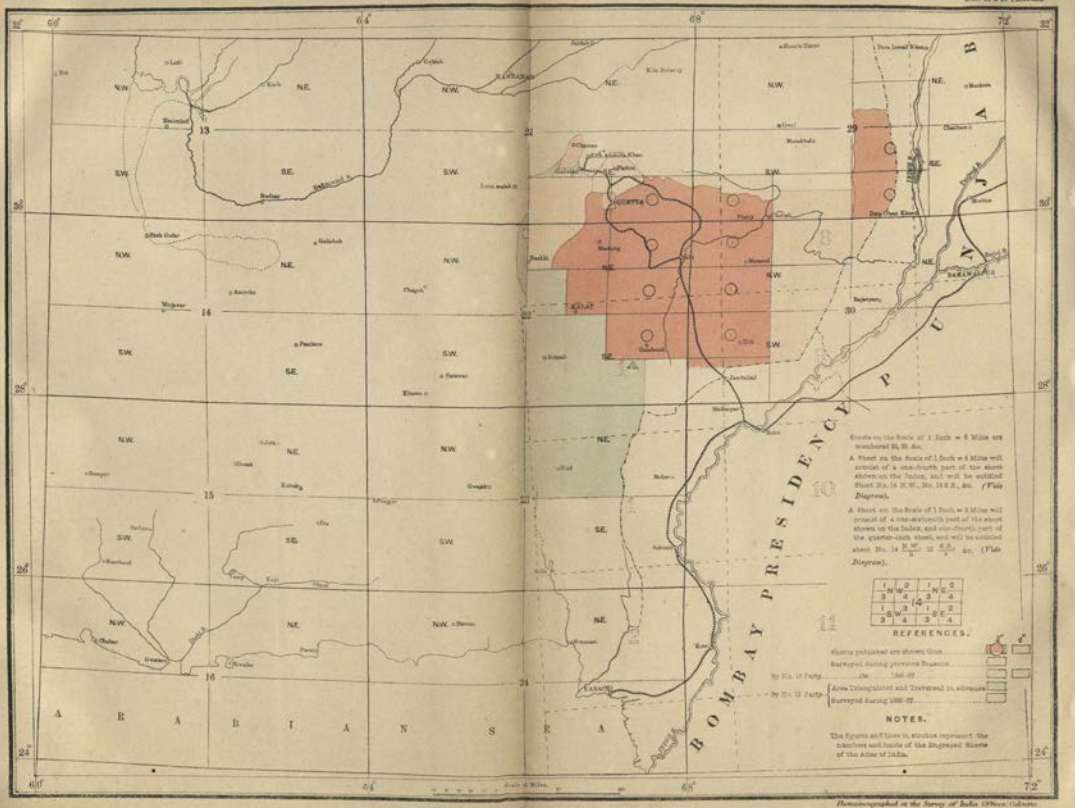
Survey of India Offices, Calcutta, March,

1888

NORTH WESTERN TRANS-FRONTIER SURVEY.

INDEX TO THE SURVEY OPERATIONS IN BALUCHISTAN.

Nos. 15 & 16 PARTIES.


66°
64°
68°
72°
32°
30°
28°
26°
24°
BOMBAY PRESIDENCY
PUNJAB
BALUCHISTAN
ARABIAN SEA
QUETTA
KALAT
SIBI
DERA GHAZI KHAN
DERA ISMAIL KHAN
KARACHI
HYDERABAD
JACOBABAD
SUKKUR
SHIKARPUR
JACOBABAD
Sheets on the Scale of 1 Inch = 8 Miles are numbered 32, 33, &c.
A Sheet on the Scale of 1 Inch = 4 Miles will consist of a one-fourth part of the sheet shown on the Index, and will be entitled Sheet No. 14 N.W., No. 14 S.E., &c. (Vide Diagram).
A Sheet on the Scale of 1 Inch = 2 Miles will consist of a one-sixteenth part of the sheet shown on the Index, and one-fourth part of the quarter-inch sheet, and will be entitled sheet No. 14 N.W. 1 S.E., &c. (Vide Diagram).
REFERENCES.
Sheets published are shown thus
Surveyed during previous Seasons
by No. 15 Party in 1906-07
by No. 16 Party in 1906-07
Area Triangulated and Traversed in advance
Surveyed during 1906-07
NOTES.
The figures and lines in circles represent the numbers and limits of the Engraved Sheets of the Atlas of India.

Published under the direction of Colonel H. H. Thuillier, R. E., Surveyor General of India.
Survey of India Office, Calcutta, January 1908.

Photozincographed at the Survey of India Office, Calcutta.

Benares' estate of Chakia and outlying detached villages, are to be surveyed on the cadastral scale of 16 inches = 1 mile. As this quantity of work was not sufficient to engage the time of a full survey party during the whole season, arrangements have been made to transfer the completion of the survey in Mirzapur to No. 4 Party, in addition to the work it has to carry out in the Basti district, and thus to set free No. 14 Party for employment in the Central Provinces, on forest surveys on the 4-inch scale which are urgently required. Operations will be commenced by this party in the Hoshangabad district, the triangulation for a 1-inch survey of which was executed in 1865-66, and this will form the framework on which the new survey will be based. The supplemental triangulation and the traverse survey will be commenced in the Rajabarári Forest Reserve, comprising an area of about 350 square miles, and subsequently the detail survey therein will be taken up. If time permits, the preliminary operations will be extended southwards to the Kalibhit reserve. Owing to the different class of work on which the party is to be engaged, the establishment has had to be reorganized, many members of which will require to be trained and great progress consequently cannot be expected at first.*

BALUCHISTAN.

No. 15 Party.

51. At the commencement of the field season Colonel Wilmer, who had held charge of the party throughout the previous year, proceeded on furlough on medical certificate, when his place was taken by Captain F. B. Longe, R.E., who has retained charge from that time, with the exception of an interval of three months in the recess season when Mr. Claudius, the senior assistant, held the office. The recess office at Mussooree closed on the 26th October 1886, and the party as per margin assembled at Jacobabad during the first week of November. The various detachments were equipped and despatched therefrom, and by the 20th idem the field operations were fairly commenced.

Personnel.

Captain F. B. Longe, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. T. E. M. Claudius, Surveyor, 4th grade.
„ E. A. Wainright, Officiating Surveyor, 4th grade.
Mr. W. C. G. Barckley, Assistant Surveyor, 1st grade.
Mr. A. Kitchen, Assistant Surveyor, 1st grade.

Sub-Surveyors.

Ahmad Ali Khan, Abdul Rasul, Husain Bukhsh, Sheikh Mohi-ud-din, Abdul Rahman, Kadir Sharif.

52. The programme for the season was the extension of the general survey of Baluchistan on the ½-inch scale in continuation of the work of the previous season, as detailed in paragraph 62, Part II of last year's Report. The general field operations were continued till 15th May, but the detachment employed on the triangulation remained in the field till the beginning of June.

53. The season's out-turn comprises the detail survey of 8,832 square miles of country on the ½-inch scale and the triangulation of 8,500 square miles in advance for future topographical survey. In addition, a theodolite traverse 70 miles in length was run in the "Pat," where triangulation was impracticable, to provide points for the detail survey. The topography was all carefully tested by Captain Longe and Mr. Claudius, and the work is said to have been found very accurate.

54. The country triangulated comprises parts of the districts of Khurásán and Jhalawán between Kalát and the Sind frontier. The work was carried out by Mr. Barckley and it proved to be an arduous and tedious undertaking owing to the intense cold which prevailed in December and January and to haze in the later months. The area was originally divided into two sections, one of which was to have been triangulated by Mr. Kitchen, but in consequence of an urgent call from No. 16 Party employed on special surveys in Pishin for another surveyor to replace an invalided officer, it became necessary to transfer Mr. Kitchen, and he was thus only able to reconnoitre a portion of the country. The whole area

* Mr. Patterson brings to notice the good work performed by Messrs. Pocock, Hamer, Potter and Kitchen, and reports that the Sub-Surveyors have all done well, especially Mohindro Nath, Karimdad Khan, and Surjan Sing.

to be triangulated therefore devolved on Mr. Barckley. Observations were prevented in a certain tract by the unsettled state of the tribes which necessitated the avoidance of that neighbourhood, and the complete programme was, therefore, not accomplished, but this portion will be finished in the ensuing season.

This triangulation was connected on the north with that executed by Captains Talbot and Wahab in 1882-83. The result, however, is not very satisfactory, which is owing in a great measure to the dense haze which spreads over the country during the months of May and June and to the fact that the cairns erected as marks for observation were often knocked down by the Brahuis as soon as erected, so that on occasions the top of the hill only could be observed to. A few observations next season will, it is expected, perfect the work.

55. The country topographically surveyed comprises portions of the Bugti and Marri hills, the Khetráni hills, the Kachi near Sibi, the Bori valley and the Luni Pathán country in the north and the juniper forests about Ziárat. Captain Longe reports that the Marri, Bugti and Khetráni countries are extremely intricate and that great difficulties were met with in obtaining water and supplies. To the north however the country is much less complicated, the valleys are wider and comparatively well inhabited, and the hill ranges which run approximately east and west, are well marked and easily surveyed.

56. The four native soldiers who had been attached to this party during the previous year were sent back to military duty after a two years' course of instruction. They were replaced by three other native soldiers who have been with the party throughout the year under report. They have shown considerable aptitude and intelligence and are capable of performing independent surveys on the ½-inch scale. During the recess season they have been instructed in drawing, in which they have made considerable progress and during the ensuing season they will be taught geographical and route surveys.

57. The health of the party during the field season was on the whole good; though owing to the extremes of heat and cold always met with in this country the season was a trying one. Captain Longe reports that during the latter part of April and in May the heat in tents in the Marri and Bugti hills was almost unbearable.

58. A small detachment comprising one European Surveyor and one Sub-Surveyor from this party and the same from No. 16 Party recessed at Quetta, to carry out any special work that might be urgently required by the military authorities. They were employed in working out the computations of the triangulation done by Captain Longe's party during the field season.

59. During the year the drawing of the fair sheets of the 2-inch survey of the Khwája Amrán range was completed, two Sub-Surveyors having been employed on it throughout the year. This survey was executed during the previous season, but owing to the shortness of the recess that year the fair-drawing could not be finished. During this recess season all the fair maps of the sheets surveyed this year on the ½-inch scale were drawn, except those of which the survey was executed during the recess by the detachment which remained at Quetta. The fair maps have been drawn with much care and skill. The computations of the season's triangulation were completed and the charts and general reports of Degree sheets brought up to date. A long report on the explorations of two Sub-Surveyors in the Registán, mentioned in paragraph 60, Part II, of last year's Report, was translated by the office writer and epitomised by Mr. Claudius. Captain Longe has written an interesting account of the country topographically surveyed, and Mr. Barckley has submitted a comprehensive report of the routes, &c., in the area which came under triangulation. These reports have been separately printed.

60. The cost-rates of this party will be found at page 72 of the appendix. The expenditure on these trans-frontier surveys is necessarily high, as explained in paragraph 59, Part II, of the last Annual Report, owing to the heavy charges for tribal escorts for the protection of the surveyors. The amount incurred on this account alone during the year under report was R23,759 or more than one quarter of the whole cost of the party. The cost of carriage also is exceedingly high.

During the ensuing season sheet 23 N. W. will be triangulated and if time admits, part of sheet 23 S. E. A series of first-class triangles will be carried from Kalát to the Great Indus Series. The topography will be taken up of

sheets 22 $\frac{S.E.}{3\&4}$, 23 $\frac{N.E.}{1,2,3\&4}$, 30 $\frac{S.W.}{3}$, and if possible of portions of sheets 22 S. W. and 23 N. W.*

BALUCHISTAN.

No. 16 Party.

61. Owing to the demands of the military authorities for special surveys on the frontier, the party that had been employed for some years past in Rajputana and Central India was transferred to Baluchistan, and Captain Wahab, R.E., who had been temporarily attached to the Himalaya Party during the absence of Colonel Tanner with the Tibet Mission, was placed in charge a short time prior to the party taking the field. Lieutenant Pollen, to whom the conduct of the party had been entrusted during the recess season of 1885-86, was transferred to the charge of the S. Maratha, or No. 10 Party.

Personnel.

Captain R. A. Wahab, R.E., Offg. Deputy Superintendent, 4th grade, in charge.
Mr. W. Todd, Surveyor, 2nd grade.
„ W. W. McNair, Surveyor, 3rd grade.
„ E. Graham, Assistant Surveyor, 1st grade.
„ G. P. Tate, Assistant Surveyor, 2nd grade.
„ B. R. Hughes, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Abdul Ghafar.	Asgar Ali Beg.
Ghulam Mahomed.	Jafar Ali.
Mahomed Husen.	Imam Bakhsh.

62. The strength of the party on taking the field is shown in the margin above. Leaving Mussooree early in October, Sibi was reached on the 22nd, and by the courtesy of the Manager of the North-Western Railway (Pishin Section) the party was enabled to travel with all its equipment over the then unopened Bolán line to Quetta, and thus the expense and loss of time which would have been incurred in the trying march through the Bolán pass was saved.

63. The original programme of work for the party was the extension of the general survey of Baluchistan on the $\frac{1}{2}$-inch scale in conjunction with No. 15 Party; but shortly after the arrival of the party at Quetta, when all preparations had been made for carrying on the $\frac{1}{2}$-inch work in the neighbourhood of Kalát, a requisition was received from the military authorities for certain special surveys which were to take precedence of all regular work, and a few days were, therefore, lost in making arrangements for the new programme. This included a detail survey, on the 6-inch scale, of about 27 square miles of country in the neighbourhood of Quetta; a 2-inch survey of the eastern portion of the Pishín plain and the Surkháb, Gwal and Kach valleys with the intervening hill ranges, also the extension southwards of the 2-inch survey of the Khwája Amrán range to include the Wach Dara, the southern branch of the Gwázha pass.

64. All this ground had to be triangulated and the computations worked out before the party could commence the detail survey, and as the whole establishment was not required for these preliminary operations, a certain number of the efficient plane-tablers were employed on the $\frac{1}{2}$-inch survey in Shorárud and Shoráwak, a part of the original programme, and this was carried out without interfering with the progress of the special surveys.

65. The out-turn of topography executed during the season is as follows:—

27	square miles surveyed on the	6-inch scale.
760	„ „	2-inch „
2,276	„ „	$\frac{1}{2}$-inch „

The 6-inch area has been surveyed in great detail, with water-levelled contours at vertical intervals of 50 feet in the low ground and 100 feet in the higher hills, while the other areas have been as minutely surveyed as the scales would admit. The necessary examinations of the field sections were made to test the accuracy of the work.

* Captain Longe reports as follows on his Assistants:—"Mr. Claudius is a very valuable assistant; his knowledge of the country, the people and the work of the party generally has been of great help. Mr. Wainwright has worked very steadily and well throughout the year. Mr. Barckley had a very long and trying season and worked very energetically. Mr. Kitchen is a very accurate and careful surveyor."

The Sub-Surveyors are generally favourably reported on, and the following are specially brought to notice:—Ahmed Ali Khan, Hussein Baksh and Kadar Sharif. The services of the writer Fateh Mahomed are also prominently mentioned in having translated a long report on the Nushki exploration out of office hours.

66. The triangulation for the 6-inch and 2-inch work was based on the side Mashelak—Usda of the Baluchistan Series, both of which stations were satisfactorily identified. From this base, triangulation was extended to the crests of the hills north of Pishin, and every opportunity was taken of fixing prominent points considerably beyond the limits of the detail survey to the north and east.

The triangulation for the 6-inch survey was completed during November and the computation and plotting of plane-tables by the 15th December, when the detail survey was commenced. In addition to the triangulated points, a number of points were fixed (and their heights determined) by traversing, which were of great assistance in the contouring.

The triangulation for the 2-inch work was completed by the same date and the computations and plotting by the middle of January. The area triangulated was about 910 square miles. Some difficulties were experienced owing to wet and cloudy weather in the high hills near Kach, but the observations were fortunately completed before the worst of the cold weather with its fogs and snow had set in.

67. Captain Wahab has submitted an interesting report descriptive of the country surveyed, which has been separately printed.

68. The party remained at work throughout the winter months without interruption, and though the operations were occasionally delayed by snow and intense cold in January and February, the health of the party did not in any way suffer. The main body of the party returned to recess quarters at Mussooree on 25th May, but three Sub-Surveyors remained in the field until the middle of June to complete the work in the higher mountains, which could not be entered during the winter months owing to the extreme cold. They were supervised by Mr. Graham, who remained with the detachment that recessed at Quetta.

69. Three native soldiers were attached to this party also, for instruction in surveying. They were taught plane-tabling during the first few months, and were eventually able to take a share in the operations, each surveying about 40 square miles of easy ground.

70. During the recess the fair maps of the whole of the 2-inch and 6-inch work have been drawn—the former in 9 sections of the standard size, the latter in 3 sections, all of which have been reproduced. The 6-inch sheets show only the instrumental contours traced in the field, and interpolated contours based on the hill sketching of the field sections, where, owing to the steepness of the ground, regular contouring was impossible. In the field sections the hills have been represented with the addition of eye contours at 10 feet vertical intervals, but owing to the shortness of the recess, time did not permit of these eye contours being drawn on the fair maps. These can be added if required at any future time, but the maps in their present state are for many purposes clearer and more useful than they would be with complete hill shading.

71. The large out-turn and excellent character of the work that has been accomplished by Captain Wahab and his assistants is highly creditable, more especially as this was the first year the party had been employed in the country, and most of the members were inexperienced in frontier work.

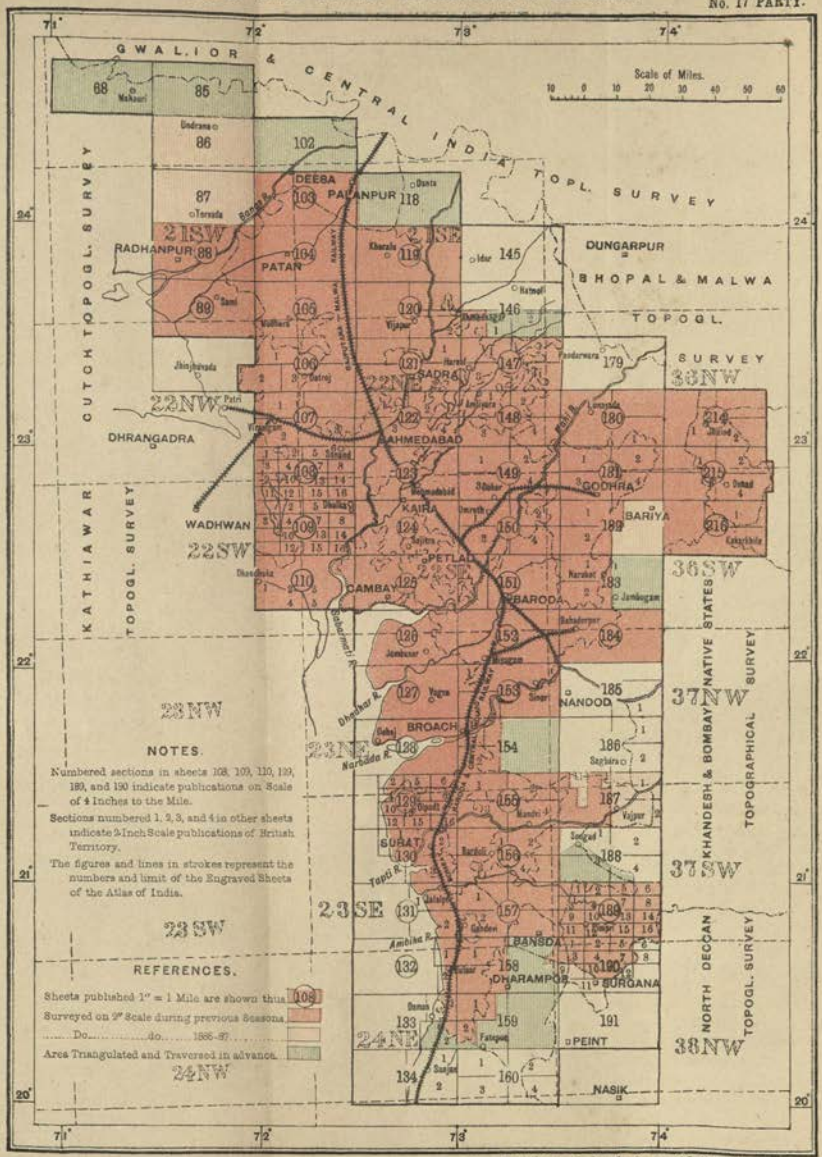
72. During the ensuing season the party will continue the general survey of Baluchistan on the $\frac{1}{2}$-inch scale as far as any special requisitions that may be made on it will admit. A first-class series of triangulation will also be carried along the 30th parallel between Dera Gházi Khan and Pishín, which, in conjunction with a meridional series, to be run by No. 15 Party, southward, to join the Great Indus Series near the 27th parallel, is intended to link the stations on the Pishín frontier with the great triangulation of India and form a final basis for extensions that may be required in Southern Afghanistan and Baluchistan.*

* Captain Wahab reports that all his Assistants worked zealously and well. Messrs. McNair and Graham did specially good work both in triangulation and detail survey; and to the excellent services of these two officers Captain Wahab attributes in a great degree the successful completion of the programme. Of the Sub-Surveyors, Abdul Ghafar and Jafar Ali worked particularly well.

BOMBAY SURVEY.

INDEX TO THE SURVEY OPERATIONS IN GUJARAT.

No. 17 PARTY.



REFERENCES.

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Nos. 68 & 85 are 43 & 85 of Rajputana Survey.

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Published under the direction of Lieut: Colonel H.R.Thuillier, R.E., *Surveyor General of India.*

Survey of India Offices, Calcutta, December 1887

GUJARAT AND THANA DISTRICT, BOMBAY.

No. 17 Party.

73. This party, which had been under the charge of Mr. J. Newland during the greater part of the previous year, owing to the paucity of available officers of the Senior Division, was at the commencement of the field season placed under the charge of Colonel Pullan, whose services became available on the completion of the Cutch Topographical Survey, and the operations during the year under report have been supervised by that officer.

Personnel.

Colonel A. Pullan, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. J. Newland, Surveyor, 4th grade.
„ G. A. Knight, Assistant Surveyor, 1st grade.
Mr. S. F. Norman, Assistant Surveyor, 1st grade.
Mr. C. Norman, Assistant Surveyor, 1st grade.
„ P. J. Serrao, Assistant Surveyor, 3rd grade.

Sub-Surveyors.

Gopal Vishnu, G. R. Bhopatkar, Bhau Gobind, Balkrishna Babaji, Govind Gopal, and 19 others.

74. The party was divided into two sections for employment on two distinct operations, and left recess quarters at Poona on 18th November 1886, one section proceeding to Surat and Pálanpur to carry on the topographical survey of Gujarát on the 2-inch scale; and the second to the Kalyán *taluka* to commence the surveys, on the scale of 8 inches to a mile, in full detail, of the Forest Reserves in the Thána district required by the Bombay Government.

75. The topographical section has completed the detail survey of 1,841 square miles on the 2-inch scale, included in sheets 86, 87, and portions of sheets 182, 187 and 190. The whole of sheets 85 and 86 consist of open sandy plains offering no obstacles to the surveyor; the portions of sheets 182, 187 and 190 that were surveyed comprise low undulating hills thickly wooded and difficult to delineate, and consequently the progress of the work was much slower.

76. In addition to the above, the triangulation of sheets 102 and 118 has been executed, comprising an area of 1,085 square miles, in advance for next season's detail survey. The boundaries between different States and *talukas* in Baroda were also traversed, aggregating 236 linear miles.

77. The topography has been surveyed as minutely as the scale would admit and its accuracy has been tested in part by 197 linear miles of check traverses, and elsewhere by *in situ* examinations made by the executive officer and his senior assistants.

78. The Forest Survey section was exclusively employed in the Thána Forests under the immediate supervision of Mr. Newland. As this was the first season of the field operations, the work was at first necessarily confined to the preliminary triangulation and traversing and the detail survey was not commenced in consequence till the 15th December, when a small squad of 6 plane-tablers was started and the remainder early in January. The character of the survey required was a topographical survey, on the scale of 8 inches to a mile, showing all details that the scale will admit. The work has proved to be one of considerable labour and necessarily of slow progress.

79. The area topographically surveyed on this scale is 53 square miles comprising the forest reserves of 43 villages of Karjat *taluka*, 18 villages of Sálsette, and 7 villages of Kalyán, including the Khairna-Pati Reserve on the Parsik range of hills. The work lies in 7 detached blocks and is confined to the hills. The range varies in height from 500 to 1,300 feet above sea-level, and though in parts it is sparsely wooded and bears but little valuable timber, still great obstruction was met with on account of the thickness of the scrub jungle which is mainly composed of *khair* and cactus. The boundaries of the forests which run round the bases of the hills, encircling each block of forests separately, have been surveyed by chain and theodolite traverse with offset measurements to boundary-pillars where necessary. The survey included the determination of contours by the water-level, differences of height having been taken at vertical intervals of 12½ feet down the spurs of the hills or at suitable distances along the hill sides, the contour lines between the water-level marks being sketched in. The water-level operations are based on the heights obtained by the triangulation; the measurements add considerably to the cost of the work, but without them the

survey would be of an inferior character, and not suitable to the requirements of the Forest Department or of the prescribed scale.

80. The accuracy of the topography of each field section was tested by *in situ* examinations, and with one exception, which required a partial re-survey, was found to be highly satisfactory.

81. The triangulation for these Forest surveys covered an area of 107 square miles by means of observations at 145 stations, the total number of points fixed being 548, the heights of which were determined. This number of heights was supplemented by the boundary traverses, the aggregate length of which is 159 linear miles, and further determinations were obtained with the clinometer to provide an efficient basis for the water-levelling operations. The area that has been prepared in advance for detail survey next season is 28 square miles.

82. The section employed on these Forest surveys suffered very considerably from fever. It is locally recognized that survey operations cannot be effectively carried out in the Thána forests between November and January, both months inclusive, owing to the prevalence of malarious fever at that time, yet to meet the requirements of the local Government, it had to be attempted, and the progress of the work was in consequence much retarded by sickness. During the current season it has been arranged to prosecute the preliminary operations of triangulation and traversing only during these unhealthy months, and to employ all the detail surveyors in Gujarát until the end of February, when the major part of them will be moved into the Thána forests, and in the three remaining months of the field season, with the stronger force that will be employed, it is expected that a larger out-turn will be obtained.

83. The field operations were continued till 31st May, when the party returned to its recess quarters at Poona. During the recess season all the fair maps of the general survey on the 2-inch scale were prepared and those of the forest survey on the 8-inch scale have been drawn in 21 sections, according to the geographical lines which are ordinarily used for limiting standard sheets, and dividing the forests into sections. In addition to the details within the forests which were surveyed, these maps show the principal topographical features in the immediate neighbourhood of the forests, which have been added by enlargement from the maps of previous surveys. They are excellent specimens of work and show that the survey has been carried out with much care and skill.

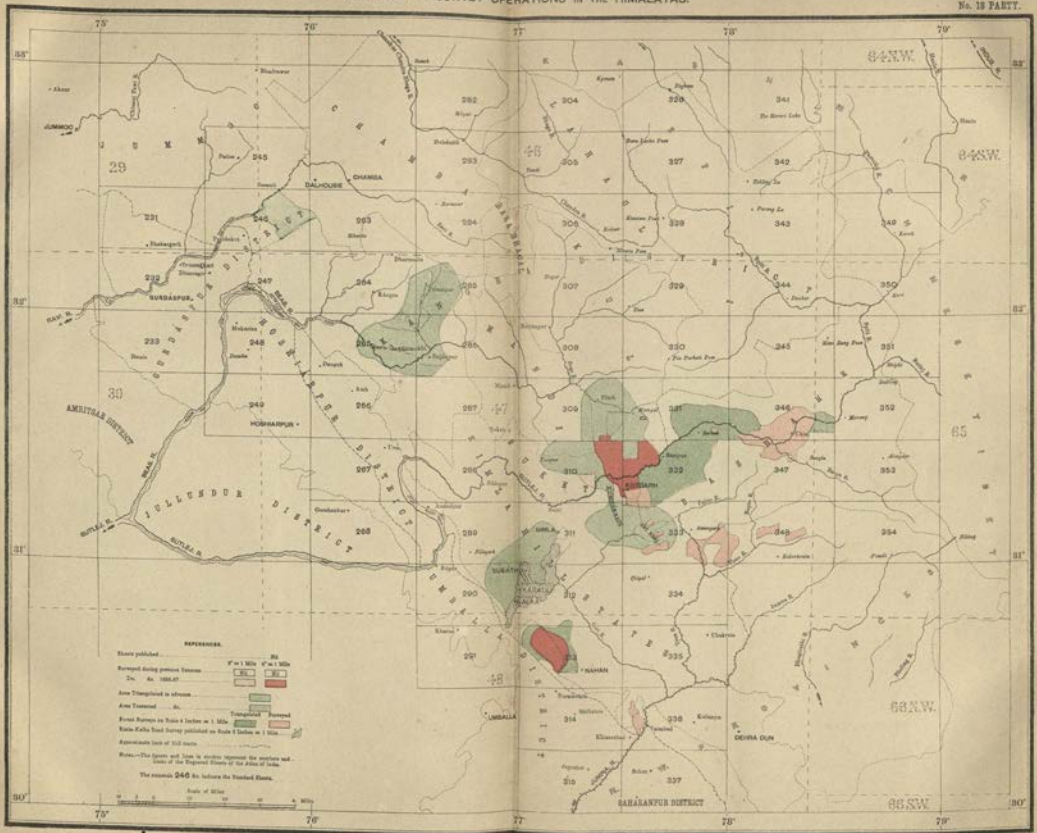
84. The costs of the different operations will be found at page 72. That of the 8-inch survey is excessive, but this is due to the operations having only recently been undertaken and to the circumstance that the proper re-organisation of the establishment for forest work, which is being carried out by training additional plane-tablers, has not yet been developed. These drawbacks, which are inseparable from new operations, are being overcome. The limited period of four months in which field operations can be carried on in the Thána forests owing to the unhealthiness of the country, also militates greatly against a large out-turn of forest work. This difficulty has been met by extending the forest survey operations over the whole of the Northern Division, instead of confining them to the Thána district, and arrangements have been made to commence, during the ensuing season, the survey of the forests of Málegaum where the country is healthy, *pari passu* with the Thána forests, whereby the field establishments can be satisfactorily employed on the survey of forests during seven or eight months each year. By this means, and with the experience that has now been obtained by the field surveyors of the work necessary for this large scale, a considerable increase of out-turn of forest surveys is expected with the corresponding result of a much cheaper cost-rate.

85. The programme for the ensuing season is for the topographical section to continue the general survey of Gujarát, on the 2-inch scale, in the northern portion of the Province, and to survey the cantonment and environs of Deesa on the 8-inch scale to meet the requirements of the Bombay military authorities; the forest section will continue the survey of the forest reserves, on the 8-inch scale, in the Kalyán and Karjat *talukas* of the Thána collectorate; and will commence the survey of those in Málegaum. A detachment comprising one European and two native surveyors will be deputed to the Rajputana Agency for employment on the disputed boundary between Meywar and Marwar in the Aravalli Hills.

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE HIMALAYAS.

No. 18 PART.



Published under the direction of Colonel H.R. Thuillier, R.E., Surveyor General of India.
Survey of India Offices, Calcutta, March 1855.

Photozincographed at the Survey of India Offices, Calcutta.

86. The recess office of this party was inspected by the Deputy Surveyor General in charge Revenue Branch, who had proceeded to Poona for the purpose of inspecting the parties under his charge which recess there. He reports that Colonel Pullan is to be commended for the style of the topographical maps that have been produced, and that credit is also due to Mr. Newland for the excellent forest maps turned out under his immediate supervision.*

HIMALAYAS, PUNJAB.

No. 18 PARTY.

87. This party has continued throughout the year under the charge of Colonel Tanner. Field work was commenced on various dates during October and November 1886, in continuation of the previous season's operations, the nature and scope of which were described in paragraph 249, Part II of the Administration Report for 1885-86. The party remained in the field *till* July 6th 1887.

Personnel.

Colonel H. C. B. Tanner, Deputy Superintendent, 2nd grade, in charge.
Lieutenant J. M. Fleming, S.C., Offg. Assistant Superintendent, 1st grade.
Mr. H. E. T. Keelan, Surveyor, 1st grade.
„ E. S. P. Atkinson, Surveyor, 2nd grade, joined 12th February 1887.
Mr. W. Robert, Assistant Surveyor, 1st grade.
„ P. F. Prunty, Assistant Surveyor, 1st grade.
Mr. F. E. Warde, Assistant Surveyor, 3rd grade, up to 1st May 1887.
Mr. G. H. Powell, Assistant Surveyor, 3rd grade.

Sub-Surveyors.

Shah Nasiruddin, Sheikh Omar, Janki Dass, Atma Sing, and 14 others.

88. The exaggerated 2-inch detailed survey, *i.e.*, a survey on the 4-inch scale in open style, showing only the details required for a 2-inch map, was completed in the Morni State in the Kotáha *taluka* of the Umballa district and was also conducted in the Outer Seoraj *pargana* of Kulu, and in the Kotgarh *tahsil* of the Simla district. The Morni State, the Sháhpur Kandi *taluka* and a portion of the Pálampur *tahsil* of Kangra were traversed. Triangulation was carried on in Morni, Shahpur Kandi, Pálampur, Outer Seoraj and the Kotkhai *taluka* of the Simla district. The separate areas completed in the different localities and on the different scales are shewn below :—

District or locality.	Description and Scale of Survey.	Area in square miles.
Umballa : Morni State, Kotáha *taluka*	Topography, 4-inch	102
	Triangulation	157
	Traversing	102
Kángra : Kulu and Outer Seoraj Subdivisions.	Topography, 4-inch	146
	Triangulation	40 exclusive of 200 square miles partially triangulated from Principal Stations.
Gurdáspur : Shahpur Kandi *taluka*	Triangulation	100
	Traversing	100
Kángra : Pálampur *tahsil*	Triangulation	216
	Traversing	70
Simla Hill States	Topography, 2-inch	35
	Triangulation	50
Simla districts : Kotgarh, Kotkhai and neighbourhood.	Triangulation	120
	Topography, 4-inch	24 inclusive of 8 square miles overlap into Hill States.
TOTALS	Topography, 4-inch	272
	Ditto, 2-inch	35
	Triangulation	683
	Traversing	272

* Colonel Pullan reports that Mr. Newland's work is excellent and his industry untiring. Messrs. S. and C. Norman have given great satisfaction both in the field and in recess. Of the Sub-Surveyors, Gopal Vishnu, G. Bhopatkar and W. Ganesh have done very good work both with the plane-table and theodolite, and in recess.

89. The bar-subtense method of traversing, which was explained in the foot-notes of page 51 of the last Annual Report, was followed, and by this means all the trijunction points of *bhojas* * and *mauzas* † in Morni, and to a great extent those of *mauzas* and *tikkas* ‡ in Pálampur were fixed in order to furnish a frame-work for the survey of the fields by *patwáris*. It has now been arranged with the Financial Commissioner of the Punjab that the Survey Department shall, in future, fix the trijunctions of these boundaries only in such parts of the country which are open and cultivated and where the hills are of moderate altitude, omitting those which are situated in high mountainous tracts, where the cultivation is much scattered, and where the *patwáris* could not be expected to make their village maps fit on to the fixed points.

90. The 4-inch topographical sheets shew the following items:—(1) boundaries of *kothis* * and *bhojas* without the boundary cairns, but including all contained trijunctions; (2) all forest boundaries with their cairns; (3) limits of cultivation and of unreserved forest tracts; (4) main lines of communication; (5) contour lines measured at vertical intervals of 500 feet in the lower hills and 1,000 feet in the higher mountains; (6) hill features, shown by lines at vertical intervals of 50 feet.

91. The contours, of which 900 linear miles were executed, have been laid down with the clinometer; this instrument was used in preference to the water-level, as it was found that owing to broken ground and to clumps of forest on the hill slopes, continuous lines could not be carried. Owing to the absence in some cases, and to the inferior quality in others, of the forest *shajra* § maps, the surveyors have had difficulty in finding all the forest boundary marks on the ground; arrangements have, however, now been made by the Financial Commissioner to ensure prompt and correct information being given to the surveyors in future.

92. The cost-rates of the work during the year under report are unduly high. This is in a great measure due to the scattered nature of the operations and partly to alterations in the previously arranged programme, but principally to failure in the work of three of the European Assistants caused by sickness, whereby the total out-turn fell far short of expectation.

93. Three soldier surveyors have been attached to the party for training, and during the year they have learnt plane-tabling and the use of the theodolite, and have executed route surveys from which they have constructed a map of the country travelled over.

94. The Director of Settlements has attached pupils to the party for plotting the 161 sheets of Morni on the 40-*kadam* scale (27·68 inches = 1 mile). They have also traced the Morni sheets, as an index to the operations of the Settlement Department in that *taluka*. ‖

MADURA AND TINNEVELLY DISTRICTS, MADRAS.

No. 19 Party.

95. The Government of Madras having accepted the proposal of the Government of India, for the transfer of the topographical work remaining to be completed in the Madras Presidency from the local Survey Department to the Survey of India Department, this party, which had just completed the survey of the

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* A *kothi*, or in the Morni State a *bhoja* is a collection of several village lands under a single *mukia* or head man, who is responsible to Government for the revenue of the *kothi*; it is therefore somewhat similar to an *iláka* in other parts of India.

† A *mauza* includes an area within convenient and generally natural limits and all the habitations therein.

‡ A *tikka* is a subdivision of a *mauza*.

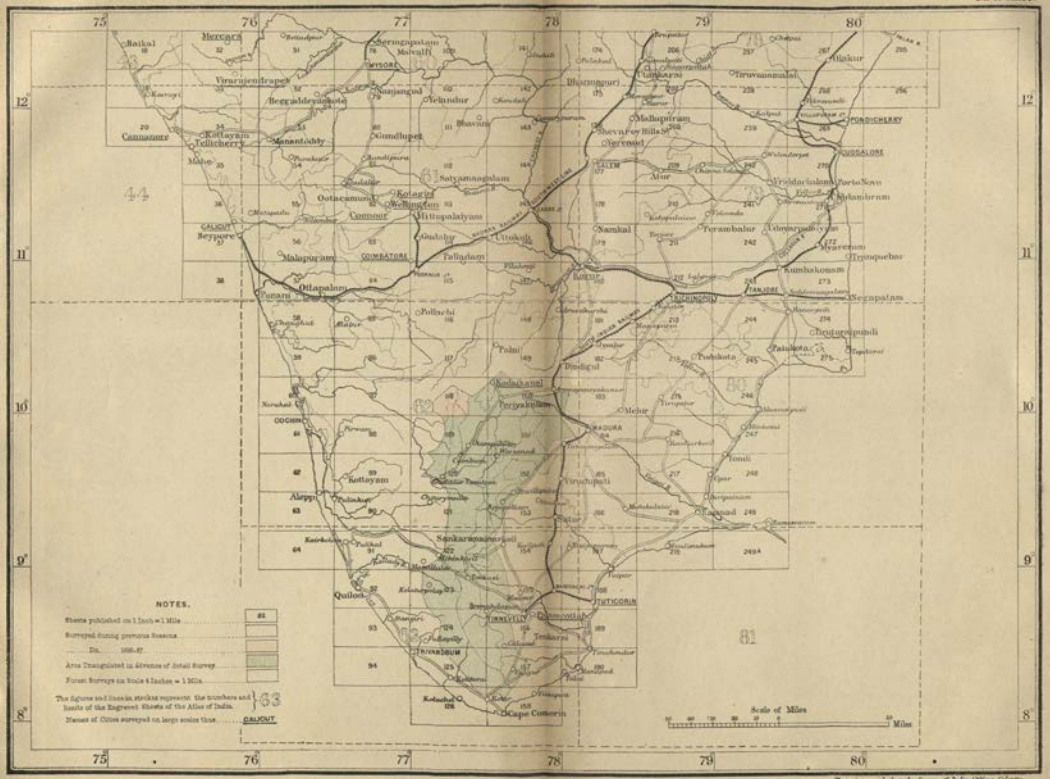
§ A *shajra* is a village map on which is recorded every individual holding of land in the village.

‖ Colonel Tanner reports favourably on Messrs. Robert, Prunty and Powell.

MADRAS SURVEY.

INDEX TO THE SURVEY OPERATIONS IN MADRAS.

No. 19 PARTY.



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Survey of India Offices, Calcutta, January 1868.

Photozincographed at the Survey of India Offices, Calcutta.

State of Mysore, was selected to undertake the work. The following are the districts in which the incompleted portions, aggregating about 12,400 square miles, will be surveyed on the 1-inch scale:—Ganjam, Vizagapatam, Tinnevelly, Madura, South Canara and Malabar. The survey of the forests in the last four districts is also to be undertaken on the scale of 4 inches to the mile.

96. The districts of Madura and Tinnevelly having been selected for the operations to be commenced in, the party proceeded thereto under the charge of Lieutenant Jackson, R.E., from the recess quarters at Bangalore. The whole of the computations, mapping, records, &c., connected with the survey of Mysore, had been completed early in October, but as the country to be operated in could not be entered with safety to health till towards the end of November, the party marched down from Bangalore, arriving at Karúr to the north of the Madura district, on the 4th November and on the 18th field operations were commenced. In the meantime Lieutenant Jackson was transferred to the Upper Burma detachment at Mandalay and Colonel Badgley took over the charge of the party from him at Karúr.

Personnel.

Lieutenant-Colonel W. F. Badgley, S.C., Officiating Deputy Superintendent, 2nd grade, in charge from 4th November 1886.
Lieutenant H. M. Jackson, R.E., Officiating Deputy Superintendent, 4th grade, in charge to 4th November 1886.
Mr. A. J. James, Surveyor, 4th grade.
„ H. Todd, „ „ „
„ R. Todd, Assistant Surveyor, 1st grade.
„ T. J. J. Mills, „ „ 2nd „

Sub-Surveyors.

Raghavayengar. | L. Jadow.
Tiruventkatsami. | B. Dhondiba.
A. Dhondiba.

97. As the country to be surveyed had not been prepared in advance for the detail survey, the operations of the whole party were almost entirely confined to triangulation throughout the season. The triangulated area that has been completed amounts to 4,370 square miles, which is considerably in excess of the area of which topographical survey is required, but it was found necessary to extend the triangulation to this extent in order to overlap the country which had been surveyed by the Madras Revenue Survey, so as to secure a good junction therewith and also to supply heights in parts where they were deficient. The triangulation was based on sides of the Great Arc Series of the Great Trigonometrical Survey and on the triangulation of the Palni hills executed by the Madras Survey. Observations were taken at 57 new stations from which 691 points were fixed and the heights thereof nearly all determined. In the area over which the detail survey is required, this triangulation furnishes on an average, about one point in every three square miles.

The country embraced by the triangulation consists of the Warasnath hills projecting eastward into the Madura district and of a long narrow strip running southwards from the Palni hills nearly to Cape Comorin, being the eastern slope of the range of which the watershed forms the Travancore boundary. Some of this ground was especially difficult, being covered with bamboos or damp forest with dense undergrowth, infested with leeches.

98. In addition to the triangulation executed, a small area of 172 square miles was topographically surveyed by Colonel Badgley in sheet 118 on the 1-inch scale. This was the only portion of unsurveyed country in which it was found that the old triangulation furnished a sufficient basis to admit of the detail survey being undertaken. It was for the most part open but exceedingly rugged and precipitous, which made it most tedious to survey owing to the difficulty in getting from point to point. The country being impracticable for carts except along the foot of the hills, coolies were the only means for transport, and they were not easy to obtain owing to the paucity of inhabitants in the hills, and to their aversion to physical labour. All supplies and the coolies themselves had to be imported generally from the villages in the plains, sometimes at a great distance from the work, which caused a good deal of delay. A description of this part of the country by Colonel Badgley will be found in the appendix at page v.

99. The field operations were closed at the beginning of May owing to rain fall, which rendered the country unhealthy, and the party repaired to recess at Octacamund. During the recess the computations and charts of the triangulation executed during the field season were completed.

100. In addition to the areas in the Madura and Tinnevelly districts that have been assigned to this party aggregating about 1,445 square miles, the survey will embrace the adjoining Native States of Travancore and Cochin, and will be carried out on the 1-inch scale *pari passu* with that of the British districts. The

existing maps of the mountainous tracts of these States, which were surveyed some seventy years ago, are very deficient. The present survey will be confined in the first instance to these tracts, as the village lands are in course of survey by the Government of these States for revenue purposes. From information received from the local Superintendent of Survey, the village maps are prepared on the scale of 16 inches to a mile and embrace all topographical details; and, as the survey is said to be based on a scientific framework, it is possible that the village plans may be utilized for preparing the topographical standard sheets of that part of the country, and endeavours will be made to secure this result, and obviate a re-survey of the portions completed by the States' Government. The programme for the ensuing season will therefore be as follows:—To extend the preliminary triangulation over the required tracts in Cochin and in the northern half of Travancore; to traverse the Travancore-Tinnevelly boundary, and to carry out the detail survey of the country that was triangulated in the last season as far as can be arranged.*

The approximate areas and the scales of survey required that remain in Madura and Tinnevelly are as follows:—

			Square miles.
In Madura	1-inch survey	. . . . .	885
„	4 „ „	(forest reserves)	10
In Tinnevelly	4 „ „	(do.)	550

NICOBAR ISLANDS.

No. 21 Party.

101. This party completed the survey of the Andaman Islands during the previous season and was under orders for Upper Burma, but the Chief Commissioner having decided that the country was still too disturbed to allow of the introduction of regular survey operations, it became available for the survey of the Nicobar Islands as had been originally contemplated.

Personnel.

Lieutenant-Colonel G. Strahan, R.E., Deputy Superintendent, 1st grade, in charge.
Mr. J. Keating, Assistant Surveyor, 1st grade.
„ D. Campbell, „ „ „
„ R. W. Senior, „ „ 2nd grade.

Sub-Surveyors.

Harlal Sing, Ali Nawaz Khan,

102. The main body of the party sailed from Calcutta on the 19th November. Port Blair was reached on the 24th November, and after discussing with the Officiating Superintendent, Colonel Wimberley, the requirements of the survey and the best means of carrying them out, Colonel Strahan embarked again and reached Kamorta on the Great Nicobar island on the 26th idem. Two of the Indian Marine steamers, *viz.*, the *Kwangtung* and the *Nankauri*, with all their boats, were placed at Colonel Strahan's disposal as well as a batch of convicts required for manual labour. An Assistant had been sent on nearly a month before to make arrangements for supplies, materials, &c., and to select and prepare a site for a base-line. His work was, however, very much retarded by the rain which fell almost incessantly from the time he landed till the arrival of the party, and indeed throughout the whole field season.

103. As it had been decided that the operations were only to extend over one season, some departures from the usual practice in commencing new surveys were necessary, the most important being that, as no elements on which to base the work were in existence, it became necessary to carry on the detail survey, the triangulation and astronomical work, all simultaneously, arrangements being made for subsequently fitting on the detail work to the stations of the triangulation, after it had been computed out on return to recess quarters.

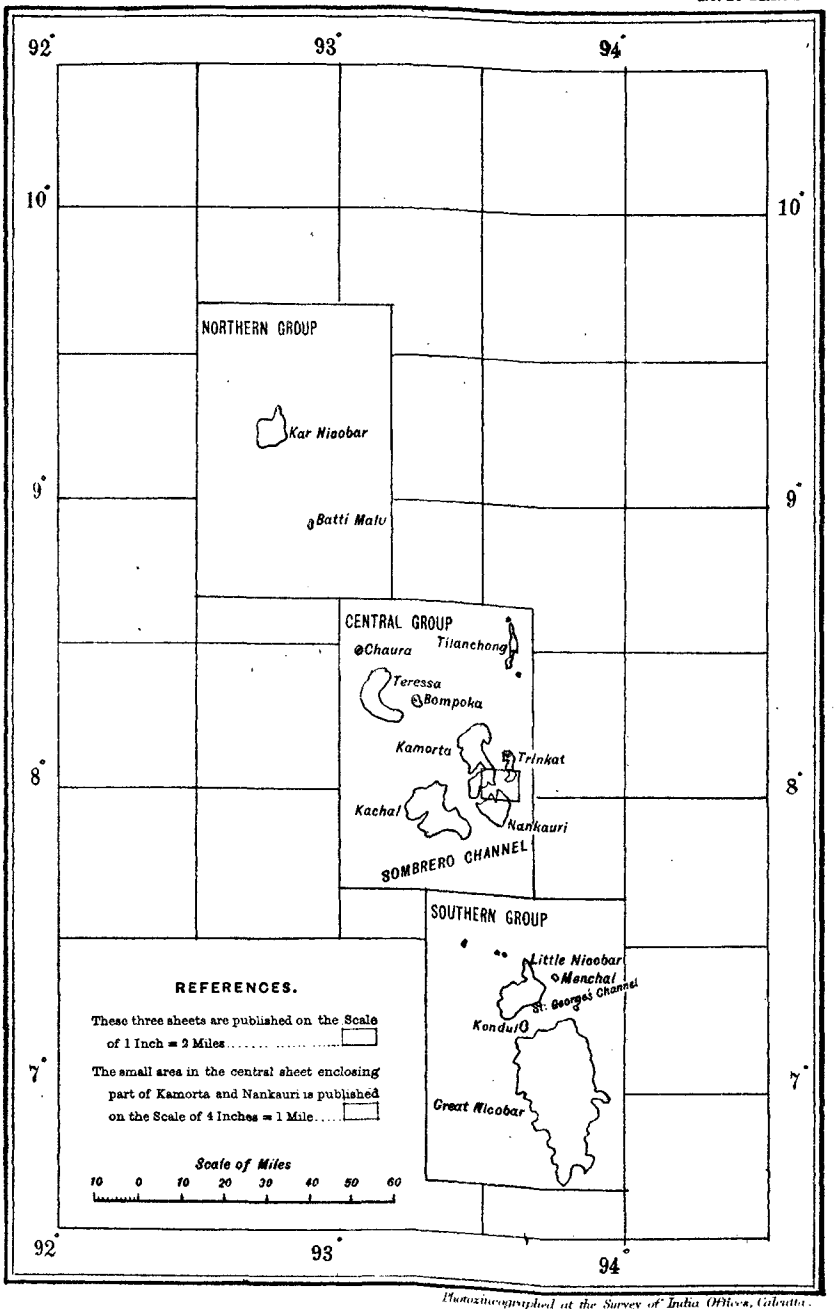
104. The objects to be attained in the topographical survey of the Nicobar Islands were four in number, *viz.*, 1st, an accurate survey of the coast lines of

* Colonel Badgley reports favourably of the work executed by all his Assistants.

NICOBAR ISLANDS.

INDEX TO THE TOPOGRAPHICAL SURVEY.

No. 21 PARTY.



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Published under the direction of Colonel H.R.Thuillier. R.E., Surveyor General of India.

Survey of India Offices. Calcutta, January 1888.

each of the principal islands; 2nd, a correct determination of the position of the Nicobar group on the earth's surface, including their relative positions *inter se*; 3rd, as much topographical detail of the interiors of the islands as could be obtained; and 4th, an enlarged plan of the settlement of Kamorta and its environs, contoured at 25 feet vertical intervals, and on a scale sufficiently large to show the various buildings, roads, drainage lines, &c., clearly.

105. Of the four objects specified above, the first two have more special reference to the requirements of navigation. Hitherto the charts of this group of islands have been confessedly very inaccurate; they were chiefly compiled from sextant observations by Danish and Austrian ships, and though not erring very grossly in the position of the islands in latitude and longitude, they are very inaccurate in the details of the coast lines, and contain no topography whatever of the interiors.

106. To meet these requirements it was necessary to arrange (*a*) for the determination of astronomical latitude and longitude at certain points, (*b*) for a network of triangulation, extending over all islands that are mutually visible, including the measurement of a base-line; (*c*) for the delineation of the coast lines; and (*d*) for the contouring and detail surveying of the settlement of Kamorta and its immediate environs, to which was added by a subsequent request of the officer in charge of the Tidal and Levelling Party—a tidal record of the rise and fall of the tide at Kamorta at 15-minute intervals for 33 days and nights.

107. The astronomical observations were undertaken by Lieutenant-Colonel Strahan and consisted firstly of a determination of the difference of longitude between Chatham Island, Port Blair and Kamorta by means of eight chronometers transported three times between the two observatories; and secondly, of the determination of the latitude of the Kamorta observatory. The longitude of Chatham Island had been determined by Mr. Nicolson of the Great Trigonometrical Survey in 1862-63 by a large number of observations of moon-culminating stars and lunar zenith distances; it was therefore deemed advisable to obtain the longitude of Kamorta differentially from Chatham Island rather than to determine it independently by astronomical observations. The method employed is such that twenty-four independent values are obtained, the probable error of their mean being only $\pm 0^{s}\cdot 11$ of a second of time corresponding to linear uncertainty of about 165 feet.

In the determination of the latitude of the Kamorta observatory there was no novelty, the usual well known methods being employed, giving a probable error of $\pm 0''\cdot 81$ of a second of arc, equal to a linear distance of about 82 feet. Latitudes were also measured at nine other points, *viz.*, five on the coast of the Great Nicobar, one at Batti Malv, one at Kar Nicobar, and two on the Little Andaman.

108. A network of triangulation resting on a measured base-line about 4 miles to the north of Kamorta was laid out, and the angles observed as usual. The islands of Kar Nicobar and Batti Malv were the only ones not embraced in this network; they therefore depend entirely on observations of latitude and longitude, in contradistinction to all the other islands of the group which are connected together by triangulation. Time did not admit of hill tops in the interior of the islands being cleared of jungle to serve as stations, and consequently clear spots on the beach were the only points available for observing from, and it is obvious that stations on the sea-level are hidden from each other at comparatively short distances, and this difficulty prevented the triangulation from being so extended as it would otherwise have been.

109. Owing to the very limited time available for this survey, it was found impossible to secure much topographical detail in the interiors of the islands. A few conspicuous peaks were fixed during the progress of the coast traverses and some of the chief watersheds and watercourses were estimated with more or less approximation to the truth, but no attempts were made to penetrate the dense forests which cover most of the islands, as other far more important work occupied the attention of the party. The heights of several inland hill peaks were measured trigonometrically; the culminating point of the whole group which stands near the north-east corner of the Great Nicobar was found to be 2,105 feet above the sea. There are also three considerable peaks in the Little Nicobar of 1,417, 1,416 and 1,355 feet respectively, and one in Tilanchong of 1,040 feet; the other islands are of less altitude.

110. The peripheries and areas of the several islands are as follows:—

	Periphery. Linear miles.	Area. Square miles.
Great Nicobar	126·5	375·7
Little „	43·0	56·8
Kamorta	65·0	57·0
Kachal	43·3	61·7
Nankauri	26·3	19·4
Trinkat	14·8	6·7
Teressa	32·1	33·8
Bompoka	7·8	3·8
Chaura	6·1	2·6
Tilanchong	25·5	9·3
Kar Nicobar	30·5	48·5
Kondul, Menchal, Kabra, Trak, Treis, Merœ, Pulo Milu, Isle of Man, and Bati Malv, together	...	2·5
TOTAL AREA	...	677·8

111. The plan of the settlement of Kamorta was made on the scale of 4 inches = 1 mile, and contoured at 25 feet vertical intervals. It is so constructed as to show the east entrance to the harbour of Nankauri and the anchorage there, as well as the position of the buoys laid down for the convenience of ships coming in there. The coast lines only of the adjacent islands of Trinkat and Nankauri are given, as it was considered unnecessary to extend the contouring to these.

112. The survey of these islands presented exceptional difficulties, and much credit is due to Colonel Strahan for the ability and readiness of resource which he brought to bear on the undertaking, the conditions of which were entirely different from those usually met with in India. Without the aid of the local authorities the difficulties would have been almost insuperable, and Colonel Strahan brings to notice the very cordial assistance rendered by Colonel Cadell and the various officers under his command, which enabled him to bring the operations to a successful completion. A very interesting account of the operations, as well as of the islands and their inhabitants, will be found in the extracts from Colonel Strahan's narrative report given at page vii of the appendix.

113. In addition to the survey of the Nicobar Islands a little extra work was done on the Little Andaman island at the request of Colonel Cadell, the Chief Commissioner of Port Blair. A portion of the coast was surveyed and two astronomical latitudes measured, one on the north point and another on the south point of the island, to supplement the previous survey of that group which had been left slightly incomplete during the previous season owing to want of time. The position of this island on the marine chart was found to be considerably in error; data now exist for correcting this, and its situation will be altered accordingly in future maps.

114. The field operations were brought to a close on the 19th April, and the recess office was opened at Mussooree on the 20th May. The results of the season's observations were then computed and the following fair maps, &c., prepared:—three sheets containing the northern, southern and central groups respectively on the $\frac{1}{2}$-inch scale; one sheet showing all three groups together on the scale of 5 miles to 1 inch, prepared especially for the use of the Indian Marine Department; a chart of triangulation; a contoured plan of the settlement of Kamorta and environs on the scale of 4 inches to a mile; and one sheet containing the Little Andaman island on the $\frac{1}{8}$-inch scale. During the next season the party will be transferred to Captain Hobday's charge in Upper Burma, absorbing the detachment already working there under that officer.

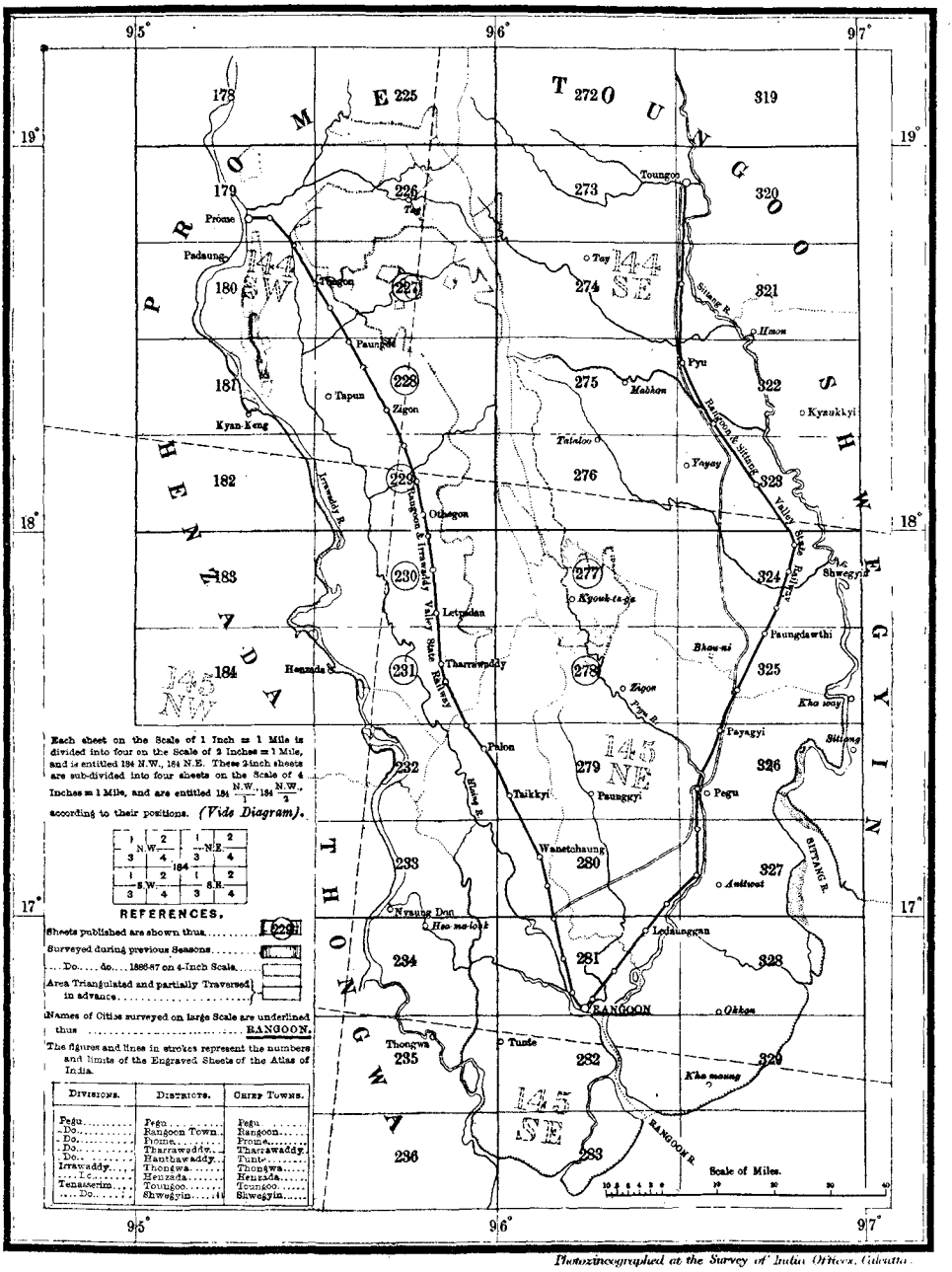
115. Owing to the varied character of the work on which the party was engaged no cost-rates can be deduced; the total cost of the operations, however, amounted to ₹39,006.*

* Colonel Strahan reports that Messrs. Keating and Campbell and Sub-Surveyor Harlal Singh have done conspicuously good work in spite of difficulties, hardships and sickness, to the effects of which the Sub-Surveyor unfortunately succumbed, having died after his return to recess quarters.

BURMA SURVEY.

INDEX TO THE FOREST SURVEYS IN LOWER BURMA.

No. 20 PARTY.



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Survey of India Offices, Calcutta, March.

1888

FOREST SURVEYS.

LOWER BURMA.

NO. 20 PARTY.

116. This party, of strength as per margin, was divided into two sections—one to continue the detail survey on the 4-inch scale of the forest reserves in the Prome district in which the preliminary operations had been completed, and the other to commence the survey of the Zamayi reserve in the Pegu district with the usual preliminary triangulation and traversing. The former section, under the immediate supervision of the Deputy Superintendent, took the field on the 12th December and the latter on the 20th November 1886. Mr. Hörst reports that the party was efficient and thoroughly organised and equipped for the field, and that a good season's out-turn was expected; but owing to the same cause that led to a shorter out-turn of work last year, namely, the unsettled state of the country and to the timidity of the native establishment, the out-turn this year has not only fallen far short of what was expected but also of that of the preceding season.

Personnel.

Mr. H. Hörst, Deputy Superintendent, 3rd grade, in charge.
Mr. A. G. Wyatt, Surveyor, 3rd grade, up to 1st January 1887.
Mr. J. H. Wilson, Assistant Surveyor, 1st grade.
Mr. C. P. Torrens, Assistant Surveyor, 1st grade.
Mr. W. H. Penrose, Assistant Surveyor, 1st grade, from 1st April 1887.
Mr. W. H. D. Ewing, Assistant Surveyor, 2nd grade, up to 1st January 1887.

Sub-Surveyors.

Venkat Swamy, Sher Shah, Durgaia, Sharfuddin, Sumer Sing, and 19 others.

117. The Sub-Surveyors told off for the detail survey in Prome were allotted work within 20 miles on either side of the Irrawaddy Valley Railway; those to the east of the line, hearing rumours of dacoits being in the neighbourhood, returned to the head-quarters camp the day after marching out, and refused to go out again unless each squad was provided with a police guard, and a guarantee was given them that Government would provide for their families in case of accidents. The *khalásis* followed the example of the Sub-Surveyors and shortly afterwards the squads of the European Assistants and of the remaining Sub-Surveyors also struck work. The men were reasoned with and every endeavour was made to induce them to return to their work, but to no effect.

118. As it was impossible to provide a police guard for each of the several detachments, it was found under the above circumstances to be futile to attempt to carry out the survey of the forests in that tract. With the concurrence of the Chief Commissioner, it was decided, therefore, to suspend operations in the Prome district and to transfer such members of the establishment for whom work could be found in the Pegu district, and to distribute the remainder among the other parties working in Burma, as reported in paragraph 139 of the last Annual Report. Mr. Wyatt and four Sub-Surveyors were then sent to Upper Burma where there was plenty of scope for the services of surveyors with the military expeditions, and five Sub-Surveyors were transferred to No. 7 Party employed in Akyab.

119. Mr. Hörst then proceeded with the remnant of his detachment to Pegu to join the section employed on the preliminary work in the Zamayi forest. The state of affairs here was almost as bad as in Prome. In the middle of December both the European Assistants fell ill, and were obliged to return to Pegu, one of them having to be sent on leave under medical certificate from 1st January. The Sub-Surveyors had stopped work, some through sickness, and others through fear of meeting dacoits, and the work was almost at a standstill, one Sub-Surveyor only, whose name, therefore, deserves mention, Modin Beg, standing to his ground and carrying on his allotted work. On the arrival of the Deputy Superintendent fresh efforts were made to push on the triangulation and to get some ground ready for detail survey. Mr. Wilson who had accompanied Mr. Hörst from Prome was detailed for this duty; he was the only efficient Assistant remaining with the party and he continued these operations till the end of the field season. The lateness of the season and the consequent haze which then prevails retarded the observations, but Mr. Wilson persevered with his work, although suffering from fever, and the triangulation was completed on the 9th April and the results roughly computed.

120. In the meantime, in order to secure a certain amount of final survey, a few traverse plots were set up and on this basis detail survey was commenced on 12th March. Sickness and bad weather continued to retard these operations which were carried on till the beginning of May when the monsoon set in and prevented further field work. The party then returned to Pegu and arrived at recess-quarters at Rangoon on 23rd May.

121. The out-turn of the season's operations was thus naturally small, comprising the detail survey of 46 square miles on the 4-inch scale, the triangulation in advance of 295 square miles of a difficult and densely forest-clad country in which the means of communication was limited to one foot-path, and the traversing of 191 square miles of which 145 square miles remain to be surveyed in detail.

122. When the advance work of triangulation and traversing has not been previously prepared, and the detail survey has to be done in the same season as the preliminary operations, the out-turn of final topography must necessarily be small, even when climatic and local circumstances are favourable. The failure of the section in Prome and the consequent disorganization of the party rendered it imperative to employ the rest of the party which could not be elsewhere transferred, in the Zamayi forests in Pegu, where the above condition existed, and considering the very adverse circumstances met with, *viz.*, the extreme unhealthiness of the country operated in, the demoralization of the native members from fear of meeting dacoits and the limited establishment employed, the small result obtained is only what could have been expected. A fair cost-rate of the final survey cannot be deduced from such a small area. The failure of the work in Prome however has been partially compensated for by the additional geographical surveys that were executed by the members of this party transferred to Upper Burma and which will be reported on under the operations of the Upper Burma Party.

123. Mr. Hörst reports that the area brought under survey, locally known as the Lower and Upper Zamayi Reserves, is very intricate, being interspersed with low hills covered with extremely dense forest and intersected with deep ravines; the undergrowth and rank vegetation therein causing it to be very unhealthy. Sickness among the members of the party was excessive, and caused much interruption to the progress of the work. The Europeans and Natives suffered equally, chiefly from malarious fever, and scarcely a man escaped it.

124. During the recess the computations connected with the triangulation and traversing were brought up, and one fair sheet was drawn and sent to Calcutta for publication. On the 11th August, at the request of the Chief Commissioner, a detachment consisting of one European Assistant and two Sub-Surveyors was deputed to the Ruby Mines District to undertake a large-scale survey of the Ruby Mines, which cover an area of about 10 square miles. Owing to sickness and bad weather, the survey operations had to be suspended for a time, and the work is not yet completed.

125. Mr. Wilson conducted an examination in surveying of Burmans, who presented themselves as candidates for the posts of *thugyis* or village surveyors.

126. The Chief Commissioner having decided to retain the party in Lower Burma for another season, in order that the survey of the areas in the Prome district should be completed without further delay to prevent the risk of the triangulation and traverse marks disappearing, it has been arranged to employ the party during the coming season entirely in the Prome district, in the first instance to survey the 255 square miles of reserved forests on the 4-inch scale, and subsequently to take up such of the unreserved forest tracts, of which an area of 280 square miles has been prepared in advance, as time will permit.

127. Mr. Hörst having proceeded on furlough, the charge of this party has been placed in the hands of Major the Hon'ble M. G. Talbot, R.E., who will superintend the operations.*

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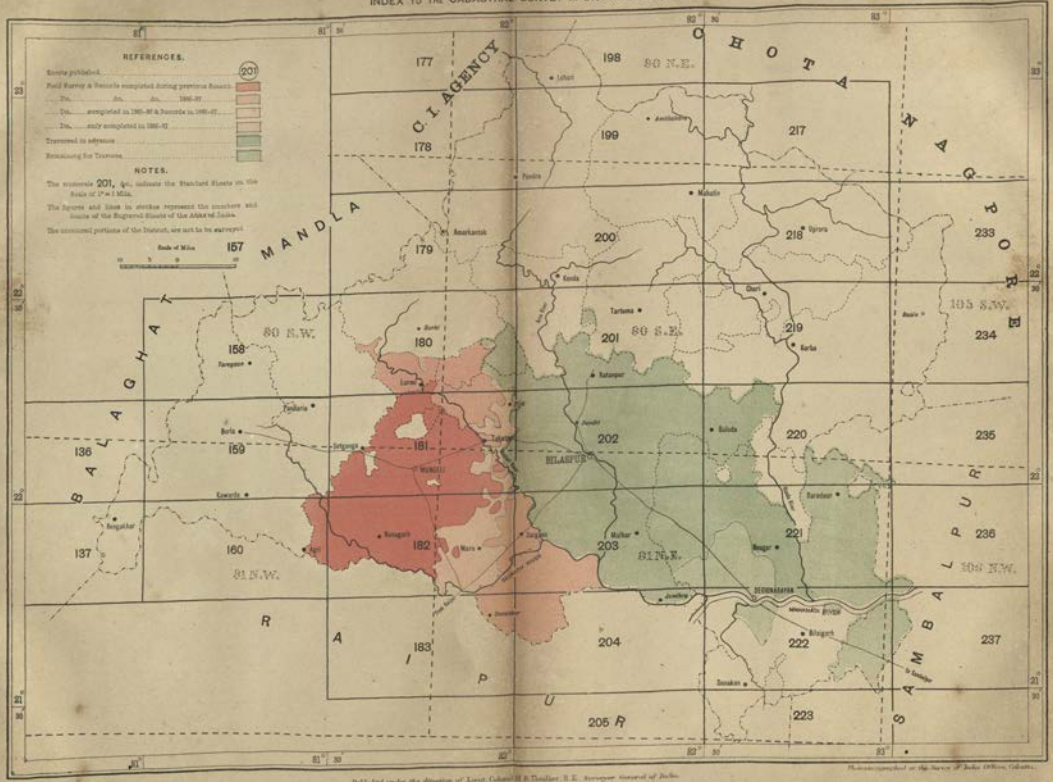
* Of his Assistants Mr. Hörst reports as follows:—Mr. Wilson worked well though he suffered throughout the field season from ill-health; Mr. Torrens was unfit for active duty, but was well employed in the camp office in computing traverses and preparing plots. Of the Sub-Surveyors Sumer Sing and Modin Beg are specially mentioned, and two young Burmans, Hpo Nyeing and Kyan Nyeing, promise to turn out well. Harlal Sing, the writer, and Fazal Haq, in medical charge, also discharged their duties well.

CENTRAL PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. BILASPUR.

No. 2 PARTY



Published under the direction of Lieut. Colonel H. S. Thuillier, R.E., Surveyor General of India.

Survey of India Offices, Calcutta, October 1897.

Photo-zincographed at the Survey of India Offices, Calcutta.

CADASTRAL SURVEYS.

BILASPUR AND RAIPUR DISTRICTS, CENTRAL PROVINCES.

No. 2 Party.

128. A change has occurred in the supervising officer of this party, owing to Colonel Steel having been compelled to take sick leave to Europe through ill health which was largely occasioned from the severe exertions and anxiety he had undergone when training a new establishment and initiating a new system in the Central Provinces. Fortunately, the Assistant Superintendent with the party, Mr. G. B. Scott, is a very able and energetic officer and he had thoroughly mastered under Colonel Steel's guidance all branches of the work required in Biláspur. The charge therefore was entrusted to Mr. Scott, and the operations have been carried on under the same system as before, except for a few modifications which the experience of a second season has led Mr. Scott to adopt.

Personnel.

Lieutenant-Colonel E. H. Steel, S.C., Officiating Deputy Superintendent, 3rd grade, in charge up to 25th October 1886.
Mr. G. B. Scott, Officiating Assistant Superintendent, 1st grade, in charge from 26th October 1886.
Mr. F. Grant, Surveyor, 1st grade.
" J. R. Scott, Assistant Surveyor, 1st grade.
" J. McHatton, Assistant Surveyor, 1st grade.
" C. S. Kraal, Assistant Surveyor, 1st grade, from 1st May 1887.
Mr. P. C. H. Smart, Assistant Surveyor, 2nd grade.
Mr. F. W. Moore, Assistant Surveyor, 2nd grade.
Mr. J. P. Barker, Assistant Surveyor, 2nd grade.
20 Sub-Surveyors and others.

Temporary Establishment.

334 Field Surveyors and others.

129. A portion of the establishment has been temporarily diverted during the season under review to the Raipur district on account of the scarcity of food-grains which had occurred in parts of the Biláspur district through a short rainfall. This change of programme was made suddenly when the field establishments were proceeding to re-assemble in the Biláspur district at the end of the recess season, and at first it was expected that the whole party would have to be withdrawn from Biláspur; but matters had somewhat improved by the beginning of November, when the surveyors had reached the ground, and the Commissioner of Chhattisgarh was then able to select tracts well-favoured with rain where employment was found for one of the cadastral sections of the establishment, while the second cadastral section had to be passed on to work in a selected part of the Dhamtari *tahsil* of the Raipur district. The traversing section of the party was retained in a part of the Biláspur district where the rainfall had been plentiful. These final arrangements received the sanction of the Government of India in Revenue and Agricultural Department letter No. 949 S.—157-3, dated 3rd December 1886. It should be mentioned here that the employment in the Raipur district of the cadastral section which could not be retained in Biláspur was rendered possible without much loss of time through traverse plots which had been prepared by the Raipur Traverse Party for the settlement survey of the district, being available for immediate use.

130. The traversing section was subsequently also sent into the Raipur district, but not on account of the scarcity. A *pargana*—Khalári—had been named for traverse survey for settlement survey purposes after that part of the Raipur district had been traversed, and its situation made its traversing more convenient for the Biláspur Party than for the Raipur Party.

131. The various sections of the party had all begun their work by the 25th November, but soon afterwards a very severe outbreak of fever with occasional cases of cholera took place, from which the sections in both the Raipur and Biláspur districts suffered severely, the total number of sick for some days reaching 120 and several deaths occurring. As a result of this outbreak the return of work was very short during December, though by January the health of the party had become quite restored. Field work was continued up to 5th May, notwithstanding the very great heat which is said to have prevailed during April. A division was then made of the office establishment for the recess, one part to be employed on completing the drawing of the cadastral sheets, calculating field areas, and finishing up the traverse computations, being taken to Mussooree, and the second part to be employed on a small share of the same duties as the first part, but mainly on the completion of all the vernacular village records, being taken to Kamptee. The officer in charge of the party proceeded to Mussooree and the Kamptee office was left in charge of Mr. J. R. Scott, Assistant Surveyor.

132. The peculiar difficulties under which the party had laboured during the previous season, the first season in Biláspur, through the want of experience of both officers and men in the preparation of village records, had been removed, and the advantage of working with a well-trained establishment, both in the rapidity and character of the work, was soon apparent. It was found possible also to increase the establishment on account of the improved capabilities of the officers for extended supervision, the result both of greater efficiency and increased strength being an additional out-turn over that of the previous season of 259 square miles. To a great extent, the acquaintance the establishment had acquired with the revenue law and village customs of the Biláspur district, as needed for the preparation of the records, was facilitated by Colonel Steel's Hand-book, specially designed for guidance in record-writing, which had been printed and put in the hands of all. A few alterations had to be made in this Hand-book, chiefly on points of law, on its being reviewed by the Settlement Officers of Biláspur and Raipur, and by the Commissioner of Settlements, but with these slight exceptions the book as originally drawn up has formed the basis of the record-writing. In the general procedure, there has been one innovation, in that new village proprietory rolls (*khewats*) have been drawn up by the Survey staff from local enquiries, the old rolls of the last settlement which had been used last year having been found to be misleading through the mutations of names not having been kept up. These new rolls will be attested with the other records at the time of settlement.

133. The average size of the fields was much smaller than those met with last year, having been ·77 of an acre in Biláspur and ·66 in Raipur against 1·03 of last season, which has occurred chiefly through the country surveyed both in the Biláspur and Raipur districts having included considerable rice-growing tracts, whereas last season mostly wheat-fields had been surveyed; and the rate of survey has been somewhat less rapid in consequence of the increased number of the field plots. In the Dhamtari *tahsil* of Raipur, there was also some delay through the want of demarcation of village boundaries, which caused the survey *amins* to be employed at first in relaying all boundaries in accordance with the old settlement survey maps, but afterwards the orders were changed for them only to relay the boundaries which were disputed, while the other boundaries were accepted as now acknowledged by the villagers.

134. During the first season, it had been found advisable to teach the operation of taking the *khánapuri*, *i.e.*, the register of tenants' rights, to only a certain number of field-surveying *amins*, partly because all the men were not acquainted with Hindi writing and partly because it was believed to be necessary that *patwáris* must assist in making the necessary inquiries; but this season, most of the *amins* having qualified to write Hindi through studying the character during the recess and being found to be competent to conduct the inquiries independently, the taking of the *khánapuri* of each village has been carried out by the same *amin* who has done the field survey. A staff of selected *amins* had however to be employed at the beginning of the season in writing up the *khánapuri* of 102 villages, in area equal to 157·34 square miles, which had been left undone during last season. This season, the *khánapuri* has been written for the entire area surveyed in Raipur, and left undone only for 38 square miles in Biláspur.

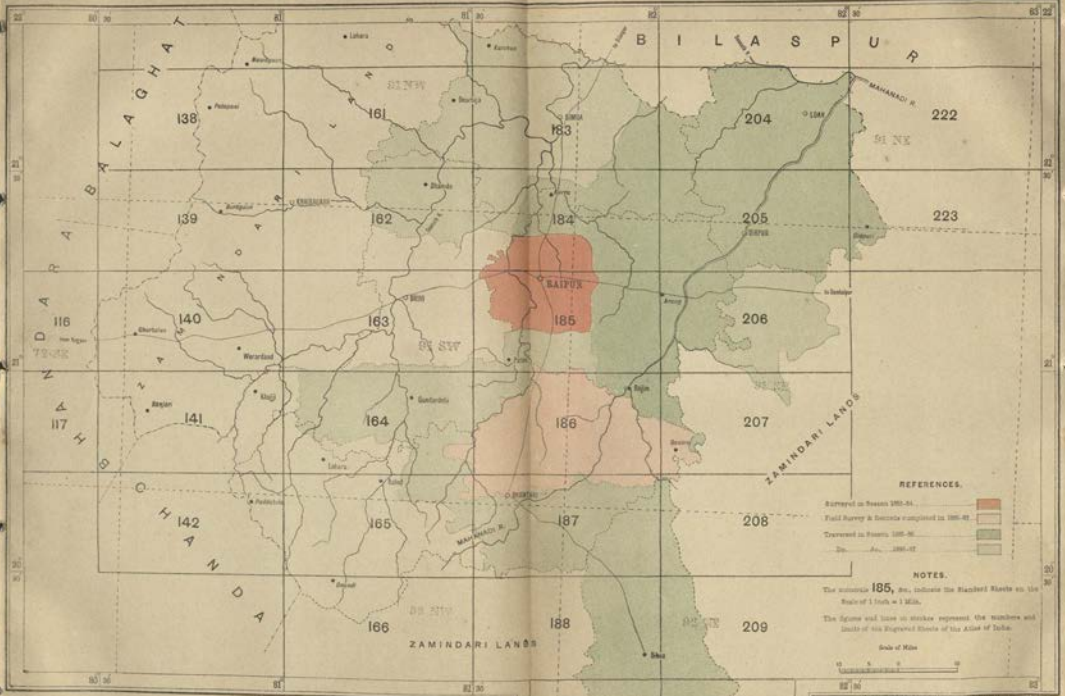
135. The following statement shows the work that has been done in connection with the cadastral survey:—

District.	Records written only (Khanapuri). Surveyed in season 1885-86.		Cadastrally surveyed and records written.		Cadastrally surveyed only.	
	Number of villages.	Square miles.	Number of villages.	Square miles.	Number of villages.	Square miles.
Biláspur	102	157·34	334	418·58	21	38·38
Raipur	...	...	342	564·72	...	...
Total	102	157·34	676	983.30	21	38·38

CENTRAL PROVINCES SURVEY.

INDEX TO THE CADASTRAL & TRAVERSE SURVEY IN DIST. RAIPUR.

Nos. 2 & 3 PARTIES.



Published under the direction of Lieut.-Colonel H.H. Tanner, R.E., Surveyor General of India.
Survey of India Offices, Calcutta, December
1897.

In Biláspur, 3,80,123 fields have been surveyed of an average size, calculated on the entire area, of ·77 of an acre, and in Raipur, the number of fields is 5,56,764 of an average, similarly calculated, of ·66 of an acre. The total number of fields in both districts is 9,36,887, and the average size calculated on the cultivated area is about ·4 of an acre. Of preliminary boundary traversing, 945 square miles have been surveyed in Biláspur; and in Pargana Khalári of Raipur, an area of 288 square miles has been traversed for the Raipur settlement survey.

136. The field survey and the entries in the records have been rigorously checked by the European officers and native *munsarims*, in the same way as last year, the tests on the survey having amounted to 362 linear miles of check survey measured by the European officers and 1,338 miles by the *munsarims;* and the entries of 62,164 fields having been tested by the Europeans and of 2,36,400 fields by the *munsarims*. For the traverse work, observations for azimuth have been taken at 41 stations in Biláspur and at 16 stations in Raipur. Connections with the Great Trigonometrical Survey were made at 3 hill stations in each district.

137. The total expenditure for the Survey year ending 30th September 1887 has been R1,46,546-3-10, from which the following cost-rates per square mile have been obtained after apportionment of the details of the expenditure, *viz.* :—

	R	a.	p.
Traversing (which includes the plotting of the skeleton maps and computation of the areas of the skeletons)	18	12	4
Marking stations	1	7	4
Detail Survey (which includes the fair-drawing of the cadastral map and of two copies, also calculation of areas of fields)	58	5	9
Khánapuri (which includes the completion of an entire set of village papers, *viz.*, *khewat, khasra, jamabandi, milán khasra, safawár khasra, jinswár, jamabandi goshwára,* and of the preparation of a duplicate set of copies of the same)	54	4	2
TOTAL	132	13	7

138. Owing to the late date on which the requisition for copies of the village papers had been received from the Settlement authorities, the records of season 1885-86 were reported in paragraph 167 of last Annual Report, not to have been ready to hand in at the close of the recess of 1886. They were eventually completed in office at Biláspur, the last papers being furnished to the Settlement Officer by the end of January 1887. This season, the copying of the records has been carried on apace with the calculation of the areas and completion of the original papers, and all the records both of Biláspur and Raipur were furnished to the Settlement Officers of the respective districts by the 6th December 1887.

139. A revised edition of Colonel Steel's Handbook of "Instructions concerning the preparation of the village papers in connection with the Cadastral Survey of District Biláspur" has been drawn up by Mr. G. B. Scott embracing a few changes found to be desirable on the experience of a second season's working and embodying the requirements of the Commissioner of Settlements and Agriculture on certain points of revenue law. A small number of copies of the revised edition have been printed.

140. The detached office of the party at Kamptee was inspected by the Deputy Surveyor General in charge of the Revenue Branch during September, when the nature of the work that was being executed and the progress of the work were found to be quite satisfactory. Mr. G. B. Scott's arrangements for the recess work in both offices at Mussooree and Kamptee, as well as his manner of government of the party in the field, have all been excellent, and do him great credit in this his first charge of a cadastral survey party. He has now to vacate the charge on Colonel Steel's return from furlough.

Mr. Scott states :—

"Before closing this report, I would mention that Mr. Hassan Khan, Assistant Settlement Officer, attached to the camp in Raipur, gave much valuable assistance both in Dhamtari and Khalári by his influence among the *málguzárs* and by his knowledge of the peculiarities and customs of the people, while his assistance and advice on legal points

concerning tenures and other questions that arose have, I trust, saved much error in the record-writing in that district."*

BASTI DISTRICT, NORTH-WESTERN PROVINCES.

No. 4 Party.

141. This party resumed operations in the Basti district in continuation of its work of last season. No changes were made in the preparation of the settlement records and statistical statements; but a slight alteration was made in the system of survey, in so much that the village boundaries, besides the stations and lines of the traverse, were plotted on the sheets issued to the *amins*, the village boundaries having been surveyed during the traversing for the purpose of ascertaining the boundaries which were disputed, and thus to provide for the settlement inquiries being instituted in time and to prevent delay in the completion of the village papers. The new system was found to answer well, and the whole of the 893 disputes except 9 were disposed of by the Settlement officials during the season.

Personnel.

Lieutenant-Colonel S. H. Cowan, S.C., Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. H T. Hanby, Surveyor, 3rd grade.
„ W. J. O'Sullivan, „ 3rd „
„ W. C. Price, „ 3rd „
„ L. F. Berkeley, Assistant Surveyor, 2nd grade.
Mr. R. F. Warwick, Assistant Surveyor, 2nd grade.
Mr. W. E. Johnson, Assistant Surveyor, 3rd grade.
21 Sub-Surveyors and others.

Temporary Establishment.

361 Field Surveyors and others.

142. Field work was commenced on the 25th October 1886, and closed on the 30th April 1887, when the party returned to recess quarters at Naini Tal. An office was at the same time established at Fyzabad where all the vernacular records were taken to be completed and for the tabulated statistical statements to be prepared. Mr. L. F. Berkeley was left in charge of this office which had an establishment of computers and writers averaging in numbers about 300 throughout the season.

143. The following table shows the out-turn of 16-inch cadastral survey :—

District.	Pargana.	Number of villages.	Area in square miles.	Number of fields.
Basti	Maghar East (part)	181	66·99	87,136
	Bánsi East (part)	895	301·97	540,623
	Rasúlpur	724	330·95	943,574
	Bánsi West (part)	156	74·29	276,021
	TOTAL	1,956	774·20	18,47,354

The traversing of the district has been completed, furnishing an area of 491 square miles ready for next season's cadastral survey. The average size of the field is ·268 acres giving 2,386 fields to the square mile. The labour involved in preparing the records and statistics of nearly two millions of fields has been very heavy, but all the *misls* except 44 were completed and despatched to the Settlement office by the 30th of September. A list of papers which constitute a complete *misl* or village record, as furnished by the survey party in District Basti, is given at page xiv of the appendix.

144. The detail survey has been checked by 2,337 linear miles of test survey, of which 306 were surveyed and compared by the European staff and 2,031 by the

* Mr. Scott reports most satisfactorily on the services of Messrs. F. Grant, J. R. Scott, and J. McHatton, in charge of sections, commending their "hearty co-operation and constant and careful attention to every detail of work."

Mr. Kraal, who joined the office at Mussooree, though much out of health, is said to have worked very well, and Messrs. P. C. H. Smart, F. W. Moore, and J. P. Barker, are all much commended for the excellent work they did in the field.

Of the permanent native establishment, the names of the following are creditably mentioned, *viz.*, Latifulah Khan, Hilaludin, Angumothu, Bholanath, Ramji Lal and Hospital Assistant Nanak Pershad.

Of the temporary establishment, the following are the names brought to notice, *viz.*, Mr. Berkeley, Mr. McGowan, Makhan Lal, Promothonath, Abdulgofur, Mahomed Idris, Karam Ali Khan, Karm Hussain Ghulam Abas and Mozaffar Beg.

No. 4 PARTY.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DIST. BASTI.

Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut: Colonel H.H. Thuillier, R.E., Surveyor General of India.
Survey of India Offices, Calcutta, September.
1867

native Inspectors. The entries in the *khasras*, &c., relating to 37,917 fields, were tested on the spot by Europeans, and 5,20,723 by Natives. To confine the angular error of the traverses, 15 azimuths were observed at an average distance apart on the main circuit of 7 miles, or at intervals of 28 angles. The traverses have been connected on two stations of the Great Trigonometrical Survey, and the average error of the chaining is shown to be 4·19 feet per mile.

145. To give a permanent value to the traversing, 4,009 traverse stations have been marked with stones, giving 6·9 permanently marked points per square mile (in addition to the village trijunctions) at a cost of R6-6 per square mile.

146. The villages surveyed have been mapped on 1,523 sheets, imperial size, suitable for reproduction by photo-zincography. Good progress has been made in the compilation and drawing of the standard 2-inch sheets of the Basti district for reduction by photography and publication on the scale of 1 inch = 1 mile. Of the 30 sections, 19 have been plotted and pentagraphed, and 13 inked up.

147. The rate per square mile for each branch of the work separately is given in the following statement:—

Head of charge.	Per square mile.	Per acre.	Per 100 fields.
	R a. p.	R a. p.	R a. p.
For permanent marks	6 6 0	0 0 1·9	0 4 3·3
„ Traversing	27 5 7	0 0 8·2	1 2 4·1
„ 16-inch survey	94 13 6	0 2 4·4	3 15 7·0
„ Khánapuri and Urdu khasra	43 6 11	0 1 1·0	1 13 1·5
„ Statistics	65 13 1	0 1 7·7	2 12 1·6
TOTAL	237 12 7	0 5 11·2	9 15 5·5 or 1 anna 7 pies per single field.

Comparing these rates with those of last season, both the rates for survey and for records are found to be considerably higher; but this is fully justified by the extremely minute subdivision of property which is quite unprecedented, the average size of the fields being a little over ¼ of an acre. The rates calculated per 100 fields are less than those of last year.

148. Four junior officers of the Civil Service, Messrs. J. S. Meston, H. D. Griffin, J. M. Wright, and H. C. Ferard were attached to the party for two months to receive instruction in surveying, and were reported to have attained a sufficient knowledge of the various processes of a cadastral survey.

149. All the *kánúngos* of the district received instruction in cadastral surveying and in taking out areas with the talc square. They have all provided themselves with a set of instruments (optical square, compasses, &c.) and, if they are kept up in their work and not allowed to forget what they have learned, should be able to carry out all the survey work that is ever likely to be required in the Basti district. No *patwáris* were available to be taken off duty and placed under instruction until late in the season, when a *patwári* school was established at Bansi.

150. The area remaining for cadastral survey in District Basti is 491 square miles, which will be completed in the coming field season. Besides this, the detail survey of Tahsil Chakia, District Mirzapur, part of the family domains of the Maharaja of Benares (the traversing of which has been done by No. 14 Party) and the completion of the topographical survey of District Mirzapur, together equal in area to about 351 square miles, have been assigned to this party. The traversing section of the party has been transferred to Bengal for employment on the survey of the Srinagar Ward's Estate in Districts Bhágalpur and Monghyr.

151. The Settlement Officer of Basti, Mr. Hooper, continues to give the survey every possible assistance; and his Deputy Collectors, especially Babu Bishan Chandra, also further the work in every way they can.

152. The recess office of the party was inspected at Naini Tal during October by the Deputy Surveyor General in charge of the Revenue Branch, who expresses himself to have been well satisfied with the character of the work that

had been executed and with the manner in which Colonel Cowan maintains the excellent organization of the party.*

GORAKHPUR AND TARAI DISTRICTS, NORTH-WEST PROVINCES.

No. 5 PARTY.

153. This party returned from its recess quarters at Naini Tal and resumed field operations in the Gorakhpur district on 20th October 1886. Field work was continued up till the end of April, when the main part of the office establishment was taken back to Naini Tal, leaving a suitable establishment in an office at Gorakhpur under Mr. T. F. Freeman to complete the vernacular records and prepare the statistical tables.

Personnel.

Lieutenant-Colonel J. E. Sandeman, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. E. G. Little, Surveyor, 3rd grade, in temporary charge from 11th July 1887.
Mr. T. F. Freeman, Asisstant Surveyor, 1st grade.
„ J. Murphy, Assistant Surveyor, 1st grade, employed on Tarai District survey from 1st December 1886.
Mr. A. W. Smart, Assistant Surveyor, 1st grade.
„ N. Bedford, „ „ 2nd „
„ W. V. Skilling, „ „ 3rd „
„ F. B. Powell, „ „ 3rd „ from 1st November 1886.
24 Sub-Surveyors and others.

Temporary Establishment.

535 Field Surveyors and others.

154. The chief work has been the continuation in the Gorakhpur district of the cadastral survey and the writing of the village papers, but a small area of forest land has also been surveyed in Gorakhpur, and a survey has been made on the 4-inch scale of certain *diwára* lands in the Sarun district of Bengal where the provincial boundary falls on the Gandak river, and an overlap survey on the 2-inch scale has been made where the boundary with the Sarun district does not fall on the river. The only change of importance in the procedure of this season is that the new classification of soils as "table land," "slope" and "low land" has been abandoned, and the old classes of "clay," "loam" and "sand," which are more readily distinguishable, have been reverted to. An endeavour was made to employ the district *kánúngos* in place of the Survey Department *munsarims*, but the experiment failed as the men were found to be very ignorant. An increased establishment was maintained during the season on the special requisition of the Board of Revenue, so as to furnish a larger area and thus to provide for the completion of the survey of Gorakhpur in two seasons, *i.e.*, by the end of season 1887-88, as required by the conditions of the expiring settlement. An additional area of 227·74 square miles beyond the out-turn of the previous season has thus been secured.

155. The following statement shows the areas of the several descriptions of survey :—

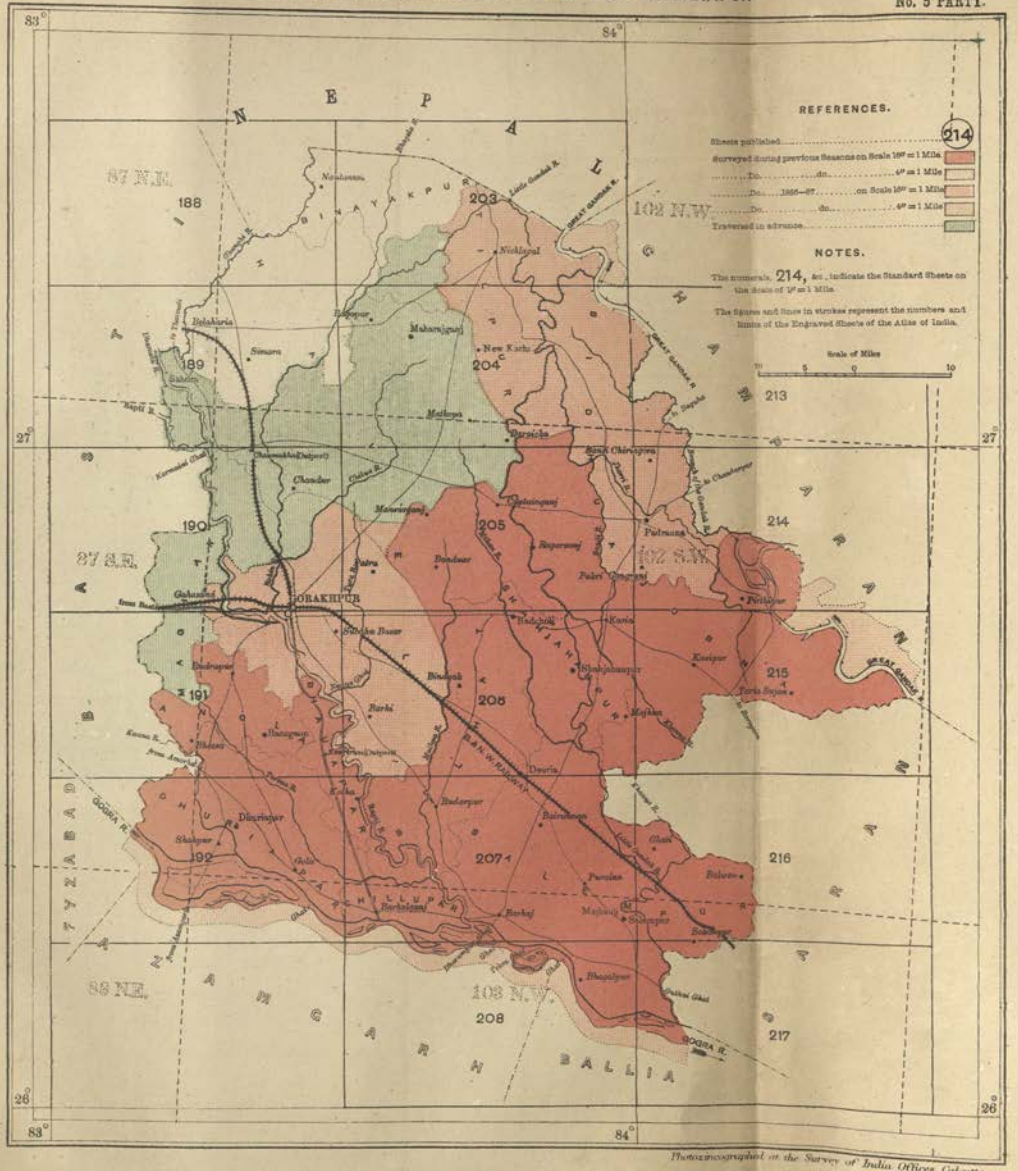
District.	Tahsil.	Description and scale of survey.	No. of villages.	Area in square miles.
Gorakhpur	Padrauna	Cadastral survey, with usual village records; scale, 16″ to a mile	570	393·77
	Maharajganj	Do. do.	289	203·43
	Gorakhpur	Do. do.	826	450·63
		Total of Cadastral survey	1,685	1047·83
	Maharajganj, Gorakhpur	Forest survey, 8″ to a mile		28·47
Sarun (Bengal)		Diwara lands survey, 4″ to a mile		71·99
		Topographical survey, 2″ to a mile		30·00

* Lieutenant-Colonel Cowan highly commends the excellent service rendered by Mr. H. T. Hanby and by Mr. W. C. Price, who had charge of the two Cadastral sections. The other members of his European staff, *viz.*, Messrs. W. J. O'Sullivan, L. F. Berkeley, R. F. Warwick and W. E. Johnson, are also favourably mentioned. Among the native establishment, Meer Asjad Ali, Ramjus Misr, Ganga Parshad and Rahimudin are mentioned as having distinguished themselves by good work.

N. W. PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. GORAKHPUR.

No. 5 PARTY.



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Published under the direction of Lieut.-Colonel H. R. Thuillier, R.E., Surveyor General of India.

Survey of India Offices, Calcutta, October.

1887

In addition to the above, preliminary boundary traversing has been executed of 1,171 villages covering an area of 775 square miles in the Maharajganj and Gorakhpur *tahsils*. The cadastral area which was surveyed includes 930,427 fields, of which the average size is ·72 acre.

156. The permanent marking of theodolite traverse stations has been carried out in the usual manner, partly with stones at selected stations chiefly at actual boundary points, and partly with burnt clay cylinders, 8,820 stations having been marked with stones and 5,782 with clay cylinders, giving an average of 7·4 stones and 4·9 cylinders per square mile; and besides these there are the trijunctions of village boundaries permanently marked previous to the survey. A large part of the cost of the stone embedding, which has amounted to ₹7,953, or 8 annas 9 pie per mark, is recoverable from the *zamindárs* for the stones which form actual boundary marks.

157. There were 924 boundary disputes in the season's area, many of which were adjusted by the relaying of former boundaries from the old 4-inch maps of 1837. The disputes on the Gorakhpur-Sarun boundary, mentioned at paragraph 175 of last year's Report, were disposed of by the Settlement officer acting as a Joint Commissioner with an officer specially deputed from Bengal.

158. The cadastral survey has been tested by 2,771 linear miles of check surveys, of which 1,660 miles were measured by Inspectors of squads during the survey and 1,111 miles by the European officers or by specially deputed Inspectors after the survey. The latter test which is the most stringent is at an average rate of about 1 linear mile per square mile of area. The angular work of the traverses was regulated by observations for azimuth at 130 traverse stations, and the chain measurements were brought into accord with Great Trigonometrical Survey distances by means of connections on eight tower stations. The comparison of chain measurements with triangulation distances showed the chaining to have been in error on an average, + or —, of 1·45 feet per mile.

159. Regarding the writing of the records, Colonel Sandeman reports as follows:—

"The *khánapuri* was submitted to the following checks. European Assistants partalled 9,076 numbers. Native *munsarims* partalled 255,731 numbers. The former is under 1 per cent., but the latter over 26 per cent. The small amount of European check is due to the time of the Assistants being so much occupied listening to disputes and endeavouring to have, *primâ facie*, the right entries made in such cases. One great difficulty to be overcome in making a correct record is to eliminate the false entries which exist in the *patwáris'* papers. In former reports specimens of such entries have been given. The *zamindár* is the real master of the *patwári*, and until measures are taken to punish the *kánúngos* very severely for permitting the *patwáris* of their circles to falsify the papers, it is hopeless to expect correct records to be kept up from year to year. I mention the following circumstances as an indication that our severe checks have had some good effect and that we have succeeded in our endeavours to make a correct record."

"The Settlement Officer tells me that about four years ago by the order of Government a return was compiled of occupancy tenants over the Province, and he finds that in the Hata *tahsil*, which he has been settling, our papers contain nearly *twice as many* of these tenants as were returned by the *kánúngos* four years ago. Some of these rights have doubtless accrued in the interval, but they could not have done so to anything like this amount, and the entries are doubtless due to the presence of the European surveyors, whose protection has enabled the tenants to assert their rights more fearlessly than they could have otherwise done. I myself have constantly found the *zamindár* striving to have fields entered in his own name as *khudkásht* on the plea that he was cultivating during the year of survey, whereas the *patwári's* record showed them to be occupancy tenants' fields. As a check against this practice, the following order of the Settlement Officer was circulated :—'The fact that an occupancy tenant does not cultivate his field in any given year, has no effect on his tenancy. He must either be legally ejected or formally resign his holding to enable it to be recorded in any other person's name."

"In the Court of Wards' villages, at the instance of the Manager, we had to adopt special measures to protect the *zamindárs'* rights against the cupidity of the tenants. All rights claimed as 'occupancy' had to be checked with the 12 years ago papers, and care had to be taken that *sáyar* items were not wrongly entered in the names of the tenants against the constitution or custom of the village."

160. The cadastral area has been mapped on 1,976 sheets, all of which were inked up by the *amins* before the village *khasra* was written, instead of the lines of field boundaries and field numbers being left to be inked up afterwards by draftsmen in office. The sheets are thus not quite so neat in appearance, but there has been no uncertainty about the boundaries or the numbers of fields as

is liable to be the case when the sheets are sent into office in pencil. A series of 8 sheets comprising the *diwára* lands of the Gandak river where the river forms the district boundary are under compilation. The plotting of the 2-inch sheets has been continued, and 12 have been sent down to Calcutta for the topography to be drawn by reduction from the 16-inch maps in the head quarters office.

161. With regard to the sale of printed copies of the 16-inch maps, which in the Gorakhpur district is carried out under special arrangements of keeping a supply of the maps in the head-quarters of the several *tahsils*, Colonel Sandeman reports :—

"Up to date, 1,559 maps have been sold to the *zamindárs* in the Deoria and Bansgaon *tahsils*, and a sum of ₹584-10, the proceeds of the sales, has been credited to Government. Although the sales have not been so rapid as was expected, still I doubt not that the small number of available maps of each village will be gradually absorbed by the people to whom these must be a great boon as a substitute for the comparatively highly-priced and difficult to obtain hand-made copies they were formerly in the habit of getting from the Collectorate."

162. The total cost of the party during the 12 months of the Survey year has been ₹1,54,441, and the rates for the season for the various works are shown in the following statement :—

	Per sq. mile.			Per acre.			Per 100 fields.		
	₹	a.	p.	₹	a.	p.	₹	a.	p.
Stone embedding	6	11	11	0	0	2	0	12	0
Traversing	20	2	8	0	0	6	2	4	0
Field survey	39	13	3	0	1	0	4	8	0
Extraction of areas and completion of maps	20	5	11	0	0	6	2	4	0
Record-writing (Khanapuri)	18	7	9	0	0	5½	2	1	0
Completion of records	5	7	5	0	0	1½	0	9	0
Abstract statistics for purposes of assessment, and soil maps	30	9	9	0	0	9	3	6	0
TOTAL	141	10	8	0	3	6	15	12	0 or 2 as. 6 pies per single field.

Under all heads the cost-rates are lower than last year, the reduction in the total rate per square mile being ₹39 nearly. This is mainly due to the fixed charges being spread over a larger area.

163. Messrs. Pike, Trethway, Legget, Hope, and Hushmat Ullah of the Civil Service have been instructed in surveying according to the usual course during the field season.

164. A school for *patwáris*, with native Sub-Surveyors as instructors, was established at Gorakhpur from 1st January, and is thus reported on by Colonel Sandeman, *viz.*:—

"Up to date, 19 *kánúngos* and 180 *patwáris* have passed the school tests in field surveying and mensuration. A much larger number could have been put through the school had the attendance been larger, but the monthly attendance has only been from 50 to 60 instead of from 125 to 150 as was intended. Each *patwári* takes on an average 8 weeks to pass through the school. The worst pupils are the *kánúngos*, who are evidently not appointed for their fitness but by interest."

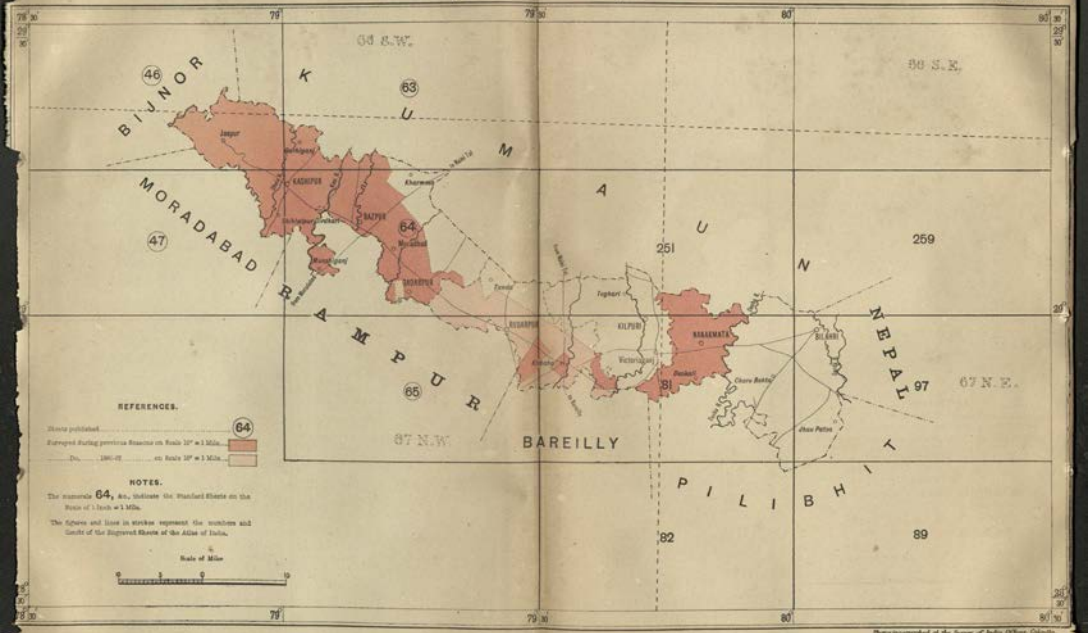
165. Colonel Sandeman writes as follows regarding the Civil officers with whom he has been associated :—

"To the Settlement Officer, Mr. A. W. Cruickshank, to Mr. Mellor, the Collector, and to his successor our best thanks are due for the manner in which they have aided us. We on our side have done what we could to prepare such maps and records as would in every respect meet their requirements, and I trust we have been fairly successful in this."

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT TARAI.

No 5 PARTY



Published under the direction of Lieut. Colonel H. E. Thuillier, R.E., Surveyor General of India.
Survey of India Offices, Calcutta, October
1887.

Photozincographed at the Survey of India Offices, Calcutta.

166. This party has furnished a detachment as per margin for cadastral survey in the Tarai district, in accordance with a requisition from the Board of Revenue, North-Western Provinces, as sanctioned by Government, North-Western Provinces, order No. 1399—I.-8 A., dated 22nd September 1886. The present survey is in continuation of the operations of a detachment of this party during seasons 1880-81, 1881-82, and 1882-83, and of those of a subsequent survey carried out under special arrangements by the Superintendent of the Tarai during season 1883-84, the plan of operations in this district having been for the survey to be undertaken according as cultivation extended and more villages became formed. A list of villages to be first taken up was supplied by the Superintendent.

Personnel.

Mr. J. Murphy, Assistant Surveyor, 1st grade, employed in Tarai District survey from 1st December 1886.
2 Sub-Surveyors.

Temporary Establishment.

8 Boundary Surveyors and others.

167. Colonel Sandeman on receiving orders to undertake this survey at once consulted with the Superintendent as to the possibility of carrying out the work through the agency of the district *patwáris*, so as to give effect to the frequently expressed injunction of the Government for these officials to be instructed in surveying and employed as surveyors whenever practicable. The Superintendent gave his hearty support to the scheme and arranged for a suitable number of *kánúngos* and *patwáris* to be brought together for instruction at the beginning of the field season; but in place of the men so withdrawn, it was necessary, the Superintendent represented, that substitutes should be entertained to carry on the current duties in the district.

168. On being put under instruction, the *patwáris* showed considerable dissatisfaction and at first refused to accept surveying as part of their legitimate duties. They were firmly dealt with by the Superintendent, who also encouraged them to work zealously by holding out the promise of appointments in the higher grades to those who should excel as surveyors, and thus they were brought under proper discipline. But there was also considerable difficulty in bringing the men to understand that their survey work must be strictly accurate, and it was only by persistent partalling on the part of the Assistant Surveyor in charge, and by the rejection of a large number of inferiorly surveyed sheets that good work was at last obtained. *Khasras* were not written during the survey. The Tarai *khasras*, on account of the cultivators having no occupancy rights, are simple documents written twice a year at the time of the spring and autumn harvests; and as the papers for the spring harvest had already been prepared, those to correspond with the maps had to be left to be written by the *patwáris*, each in his own circle, at the autumn harvest in August. The operations were begun about 6th December 1886, and were closed about 15th May 1887, when the detachment went into recess quarters at Naini Tal.

169. The out-turn of the season is shown in the following statement:—

Parganas.	Scale of survey.	No. of fields.	Acres.	Sq. miles.	Remarks.
Bazpur . . } Gadarpur . . } Rudarpur . . }	16″ to a mile.	31,078	48,896·2	76·40	The average size of the fields is 1·57 acre.

The boundary traversing has been done for the above area as well as the field survey. No traversing could be done in advance for next season on account of a very severe outbreak of cholera which put a stop to further field work sooner than was intended. All the traverse stations have been marked either with stones or with burnt clay cylinders, the marks having had mounds of earth raised over them, and being placed under charge of the village *patwáris*.

170. The traverse survey is an extension of what had been done in the Tarai in previous years. It has been checked by observations for azimuth at eight traverse stations, and has been connected with six stations of the Great Trigonometrical Survey. To test the survey of the fields, 1,019 lines of check surveys were measured, averaging 17 lines in each village. In length, these lines aggregated 360 linear miles, or 4·7 miles per square mile.

171. The Assistant Surveyor in charge rendered assistance to the Superintendent of the Tarai in settling eight boundary disputes, including three with the Rampur State, by furnishing maps of the disputed lands with the lines of old boundaries added. A Sub-Surveyor was deputed to accompany the Superintendent to the Nepal boundary on the Sarda river, where a survey was required to determine the sites of old boundary pillars which had been washed away.

172. *Patwáris* have only been employed for part of the recess work, as the Superintendent found he could not spare more than eight men at a time; they have done about three-fourths of the area computations and about one-fourth of the mapping.

173. The 60 villages surveyed during the season have been mapped on 113 sheets, of each of which two tracings have been furnished to the Superintendent. *Khasra* forms with areas entered in acres and *bighas* have also been furnished in readiness for the *khánapuri* when it will be taken. The villages will in due course be mapped on the 4-inch scale by reducing the 16-inch maps, and it is proposed to add to the series of 4-inch maps which were begun during the surveys of the other parts of the Tarai.

174. The total cost of the detachment has been R10,579, of which R862 was paid to *patwári* substitutes according to terms arranged with the Superintendent. Excluding the amount paid to the substitutes, the rates per square mile for the different works are as follows:—

	R	*a.*	*p.*
Stone embedding	4	7	5
Traversing	38	1	5
Field survey, including the computation of areas and entering them in the khasra forms	56	7	0
Khanapuri		*nil.*	
Instruction of patwaris	28	3	1
TOTAL	127	2	11

175. Sanction (by North-Western Provinces Government order, Revenue Department, No. 738—I.-8 A., dated 4th June 1887, to the Secretary, Board of Revenue) has been given for a continuance of the cadastral survey over Parganas Kilpuri and Bilhari on the same system; and a grant of R11,500 has been allotted for the work for the Revenue year 1887-88.

176. The recess office of the party at Naini Tal was inspected during October by the Deputy Surveyor General in charge of the Revenue Branch, who testifies to the continuance of Colonel Sandeman's excellent arrangements for the organization of his large establishments, and to the maintenance of the same high character in the maps and records as in former years. During Colonel Sandeman's absence on three months' privilege leave, Mr. E. G. Little has carried on the executive duties very efficiently.*

* Colonel Sandeman commends the good work done by Mr. E. G. Little while in charge of the party for three months. Messrs. T. F. Freeman and A. W. Smart in charge of sections are reported to have worked "in their usual zealous and thorough manner," and they are said to have been so well aided by their assistants, Messrs. N. Bedford, W. V. Skilling, F. B. Powell, and J. H. Murphy (Office Assistant), that a very large amount of work was brought up to date and the field would be taken with no arrears.

In connection with the Tarai survey, Colonel Sandeman reports:—

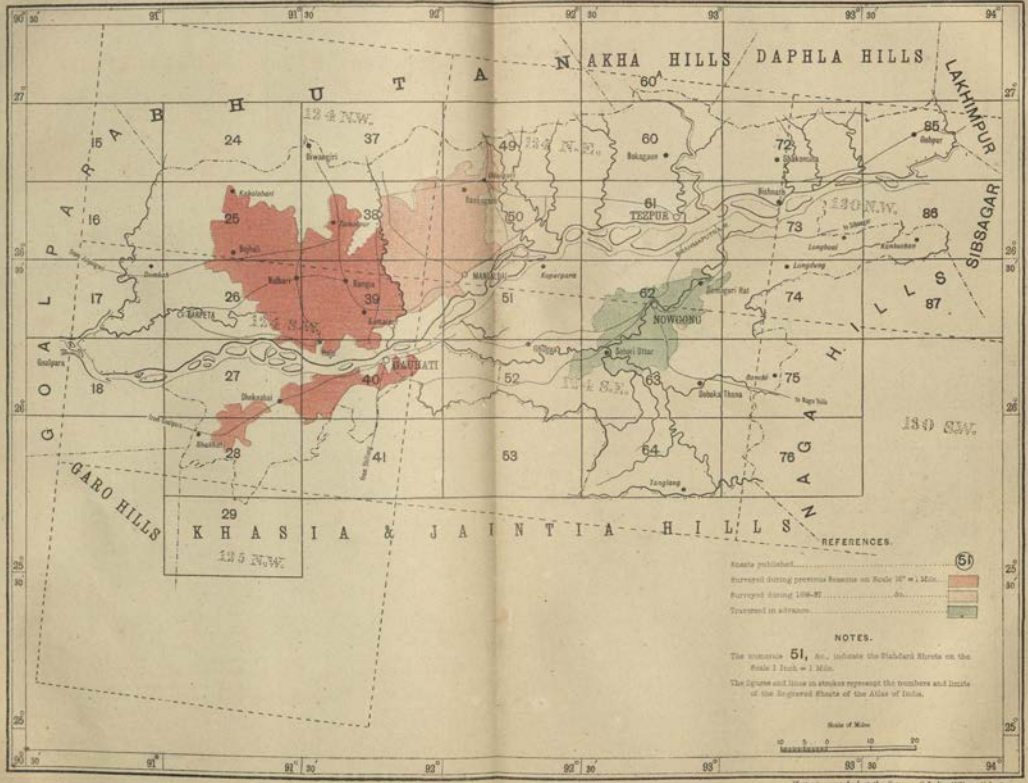
"Mr. J. Murphy, Assistant Surveyor, who has been in immediate charge of these experimental operations, deserves great credit for his management of the *patwáris* and for the manner in which he instructed them, and for his conduct of the entire operations."

Of the native establishment, Colonel Sandeman gives the following names as being deserving of mention, *viz.*: Puran Chand (who helped in the instruction of the junior Civilians), Nidha Lal, Golamgous Khan, Joala Pershad, Hari Singh, Dhanpat Rai, Amanat Hosain, Farhat Ulia, Babu Ram, Har Sahai, Jai Narain, Waris Ali, Bhoj Raj, Maula Bux, and Badri Pershad

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTS. KAMRUP, DARRANG, & NOWGONG.

No. 6 PARTY.



Published under the direction of Lieut. Colonel H.B.Thuillier R.E. Surveyor General of India.
Survey of India Office, Calcutta. September.
1857

Photozincographed at the Survey of India Office, Calcutta

DARRANG AND NOWGONG DISTRICTS, ASSAM.

No. 6 Party.

177. This party under Mr. Barrett has carried on cadastral operationsin the Darrang district, where the whole area required to be cadastrally surveyed has been completed, and has executed preliminary boundary traversing in the Nowgong district. Both operations were begun on 10th November and were closed together on 10th May, when the office establishment returned to Shillong.

Personnel.

Mr. E. C. Barrett, Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. J. H. O'Donel, Surveyor, 4th grade.
" D. A. King, Surveyor, 4th grade.
" J. Connor, Surveyor, 4th grade.
" M. Gastaud, Assistant Surveyor, 2nd grade.
" J. Smith, Assistant Surveyor, 3rd grade.
24 Sub-Surveyors and others.

Temporary Establishment.

159 Field Surveyors and others.

178. The field season was particularly unhealthy. Cholera was prevalent in District Nowgong during the months of November and December, and occasioned three deaths among the Hindustani *khalásis*. In Darrang there was only one death from cholera, but an inspector, 2 *amins*, and 6 measurers (all Hindustanis) died from fever and other complaints; and during the recess, information was received of the deaths at their homes, victims to the unhealthy Assam climate, of 1 inspector, 4 *amins*, and 8 measurers, making a total of 26 deaths in all, or 8 per cent. of the entire up-country field establishment. It is not surprising that service in Assam is not regarded with favour by Hindustanis, and that each year the party has had to work with from 40 to 50 per cent. of new hands. The need for the almost exclusive employment of Hindustani *amins* (Bengalis have only been procured in the proportion of 1 to 4) will, it is hoped, be obviated in future by a plan which is about to be tried of working with the village headmen (*mandals*) as surveyors.

179. The nature of the cadastral operations in Darrang has been the same as previously carried on in Kámrup, *i.e.*, a field survey by *amins* on the 16-inch scale, with a village *khasra*, which in Assam is little more than a simple register of tenants, the tenures of all being almost alike. Separate copies of the *khasras* are written by *amins* and village headmen (*mandals*) simultaneously, each in his own vernacular. The area for cadastral survey in Darrang, which is a very small part of the total area of the district, had been determined by the Provincial authorities with consideration to the main tract where the cultivation is permanent. This tract had been prepared for survey by boundary traversing during the previous season, but this season it has been increased, with the sanction of the Chief Commissioner, by adding a strip of fairly well cultivated country to the north of the original tract and the whole area thus surveyed, which is all that is intended to be surveyed in Darrang, amounts to 547·02 square miles. The entire area includes 29 whole *mauzas* and 7 portions of *mauzas*, which (as mentioned at paragraph 185 of last report) had not, previous to the present survey, been formed into villages and have now been subdivided into 630 villages of an average area of 555 acres.

180. The boundary traverse survey has been executed over an area of 456·45 square miles, of which 70·8 square miles are in Darrang, being the area which was added afterwards to the tract originally selected, and 385·65 square miles are in District Nowgong in preparation for next season's cadastral survey. In Nowgong, as was the case in Darrang, the *mauzas* are being subdivided during the traverse survey into villages of convenient size.

181. For the traverse survey, observations for azimuth have been taken at 27 stations, and connections have been made with two stations of the Great Trigonometrical Survey. The cadastral survey and the village records were carefully tested by the European officers and by native Inspectors who constantly moved about among the *amins* in the field, and on the occasion of each visit being attended by the *ráiyats* interested, examined, plan in hand, the *khasra* entries of not less than 10 per cent. of the fields surveyed since the last visit. The field measurements were also tested in the usual way by check lines measured after the survey, of which an aggregate length of 353 linear miles was executed by European officers and 803 miles by native Inspectors, both together furnishing an average check of 2 linear miles to each square mile of survey. The work

was also examined by *munsarims* and Sub-Deputy Collectors of the Settlement Department, who gave particular attention to the *khasra* entries.

182. All village tri-junctions are marked by stone prisms 3 feet long with 1 foot sides. The intermediate traverse stations are not marked, but the position of all are indicated by *semal* trees, one of which is planted at a distance of 5 feet to the magnetic north of each station point. In District Darrang it was found that 50 per cent. of these indicating trees planted during the previous season had failed to take root and they have been re-planted.

183. The area surveyed is mapped on 718 sheets; tracings from which, together with the original *khasra* books with field areas entered in acres and in local measures, were all furnished to the Settlement Officer by the 24th September.

184. In accordance with established procedure, revision parties were sent out at the beginning of the season to the areas surveyed in District Kámrup during season 1885-86 to investigate the objections raised by the holders of land against the composition of their holdings as determined by the cadastral survey. The operations were completed by the 22nd January, 210 villages out of 319 having been passed without requiring corrections of any kind. As the revision work progressed, the cadastral sheets after correction were sent down to Calcutta to be printed and all had been despatched by the 30th March.

185. A small hand-book, drawn up by Mr. Barrett, embodying the instructions issued from time to time to officers in charge of sections "concerning the methods of preparing the village papers adopted in connection with joint survey and settlement operations in the Assam Valley districts," has been printed and is in use as a book of reference in the party.

186. The cost-rate of the survey for the season is ₹198-14-3 per square mile, and ₹1-11-4 for the revision survey, both rates being slightly less than the rates of last season. The rates for the settlement operations have not been ascertained.

187. Regarding the financial advantages which have been derived from the operations of the survey and settlement in District Kámrup, Mr. Barrett furnishes the following particulars, showing that the expenditure on the operations has been amply justified on financial grounds only, and adducing evidence concerning the circumstances of the present assessment in the parts of the district from which the survey has been excluded, which afford good proof of the need for an extension of the operations :—

"The financial results of the three years of survey and settlement in District Kámrup by cadastral survey and *mauzadári* papers are given in the following comparative statement :—

Year.	Total area of assessable cultivation in Acres		Revenue.		Increase.
	By Mauzadár's papers.	By Cadastral papers.	By Mauzadár's papers.	By Cadastral papers.	
			₹	₹	₹
1883-84	1,04,007	1,08,284	1,25,183	1,33,542	8,359
1884-85	1,79,417	1,85,788	2,30,077	2,40,569	10,492
1885-86	1,34,220	1,39,307	2,29,534	2,43,243	13,709
	4,17,644	4,33,379	5,84,794	6,17,354	32,560

"The total expenditure on combined survey and settlement operations in Kámrup, including revision survey, amounted to ₹3,61,166-12-10, and the increase of revenue, as shewn above, to ₹32,560, giving 9·01 per cent. on the outlay.

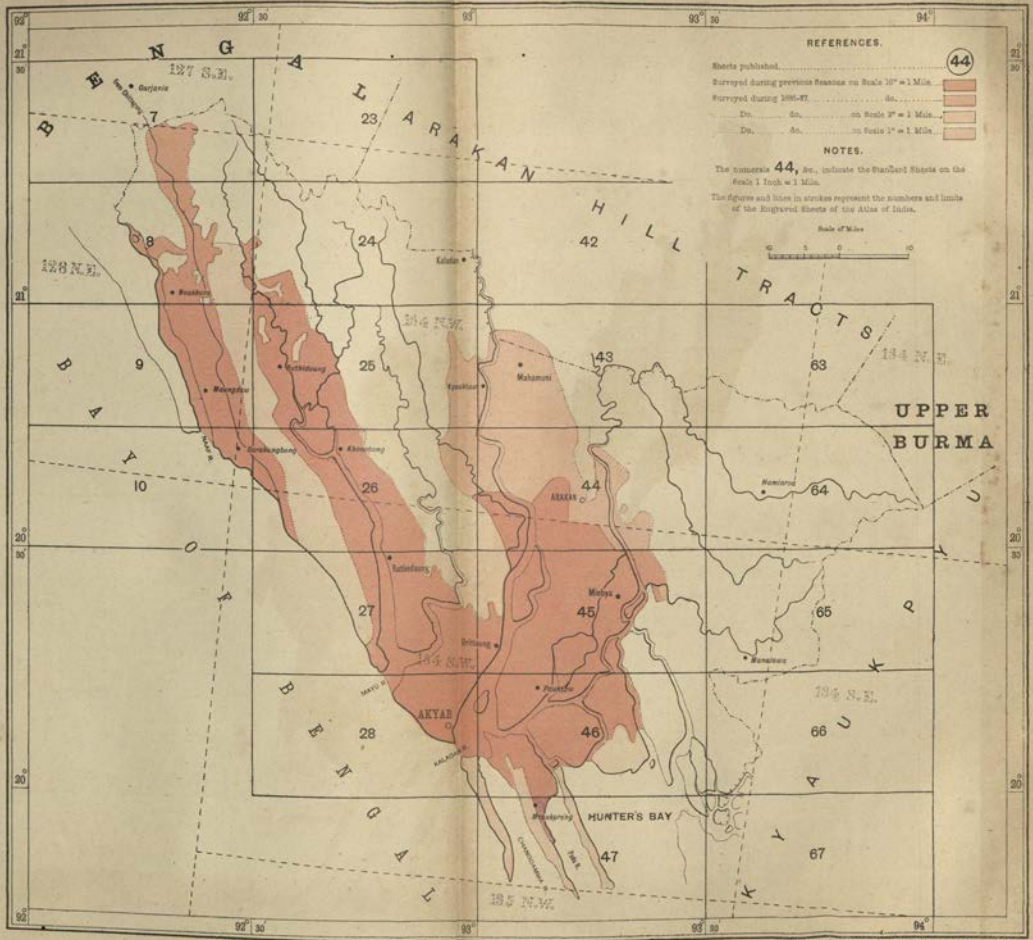
The proportion of the increase of revenue to expenditure during each of the three years of survey was—

For 1883-84 . . . . . 8·41 per cent.
„ 1884-85 . . . . . 7·44 „
„ 1885-86 . . . . . 11·33 „

LOWER BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. AKYAB.

No. 7 PARTY.



Photolithographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut. Colonel H. H. Thuillier, R. E., Surveyor General of India.

Survey of India Offices, Calcutta, November 1897.

The figures prove that the survey has, apart from administrative considerations, paid its way each year.

Survey operations in Kámrup were, as far as practicable, confined to the closely populated and most frequented tracts where land is valuable and competition for it keen; but it is a noteworthy fact that the largest increases to the revenue have been obtained from the least accessible and sparsely cultivated areas, and more especially from those *mauzas* where the cultivation is *faringhati* or fluctuating. The figures for a few of the jungle and *faringhati mauzas* given in the following table will afford some idea of the extent to which an increase of revenue might fairly be hoped for, if the scope of survey operations were extended to all cultivated tracts:—

Mauzas.	Classification.	Revenue on Khiraj lands		Percentage of increase of revenues.
		By Mauzadár's papers.	By Cadastral papers.	
		₹	₹	
Borigog	Faringhati	13,441	19,603	45·8
Dephali	Jungle	1,252	1,465	17·0
Sela Sindurighopa	Do.	6,303	7,157	13·5
Hajo	Faringhati	12,830	14,704	14·6
Jhargaon	Jungle	1,347	1,441	7·0
Bekeli	Faringhati	3,306	3,562	7·8
Bangaon	Do.	2,960	3,494	18·0
Bardnar	Do.	12,306	13,821	12·3

The cost of the survey and settlement of the eight *mauzas* at average rates amounted to ₹51,178 and the increase of revenue to ₹11,502, which is equal to 22·47 per cent. on the expenditure.

188. The Chief Commissioner of Assam, Mr. W. Ward, inspected the field offices of the party at Kolaigáon on 14th April 1887

189. Mr. Barrett reports as follows on the assistance he received from the Civil Officers with whom he was associated:—

"Very satisfactory arrangements were made for furthering survey operations in Districts Darrang and Nowgong by their respective Deputy Commissioners, Colonel Campbell, and Mr. Knox Wight. The acknowledgments of the Deputy Superintendent are also due to the Settlement Officer, Rai Sarat Chunder Banerjee, Bahadur, for his cordial and efficient co-operation with the survey throughout the year."*

AKYAB, BASSEIN AND THONGWA DISTRICTS, LOWER BURMA.

No. 7 Party.

190. This party remained under the superintendence of Lieutenant-Colonel H. S. Hutchinson until he proceeded on leave on 28th June, when it was placed under the temporary charge of Mr. H. R. Littlewood, Surveyor, who was relieved on 5th September by Mr. F. W. Kelly, appointed to succeed Colonel Hutchinson (who had been transferred to another party) in the permanent charge.

Personnel.

Lieutenant-Colonel H. S. Hutchinson, S.C., Officiating Deputy Superintendent, 3rd grade, in charge up to 28th June 1887.
Mr. F. W. Kelly, Officiating Deputy Superintendent, 4th grade, in charge from 6th September 1887.
Mr. H. R. Littlewood, Surveyor, 2nd grade (in temporary charge from 29th June to 5th September 1887).
Mr. J. A. Barker, Surveyor, 4th grade, from 4th November 1886.
Mr. G. W. Jarbo, Assistant Surveyor, 1st grade.
" J. S. Swiney, Assistant Surveyor, 1st grade.
" P. Beechey, Assistant Surveyor, 2nd grade, from 7th December 1886.
Mr. G. S. Willes, Assistant Surveyor, 3rd grade, up to 31st July 1887.
27 Sub-Surveyors and others

Temporary Establishment.

94 Field Surveyors and others.

191. The party during the field season was divided into two main sections, one section being retained in the Akyab district to complete the area required to be surveyed cadastrally, as well as to conduct a topographical survey of portions of hill ranges which stretch into the cadastrally surveyed parts of the district; and the second section being despatched to the Bassein district to resume cadastral opera-

* Mr. Barrett specially commends the good services rendered by Mr. J. H. O'Donel, and reports favourably of Messrs. King, Connor, Smith and Gastaud.
Of the native establishment, the following names are given as deserving of mention, *viz.*,—Mohan Singh, Tajjudin, Sahkawat Hossein, Khurshed Hossein, Amjad Khan, Janardhan Rao, Saroda Prosad Chuckerbutty, Ganga Ram, Ghulam Hyder, Audur Chunder Ghosh, Jhuni Lall, Harack Narayan, Eusuf Hossein, Mosan Ali, and Anwar Hossein.

tions there in certain circles which have been named for survey since the time of the previous operations in the district, as well as to initiate the cadastral survey of selected circles in the Thóngwa district. The Akyab section moved out into camp from its recess quarters at Akyab on 3rd December, the cadastral part of the section continuing at work up to 8th May and the topographical part up to 30th May. The office portion of the section was then moved to new recess quarters at Rangoon. The Bassein section left Akyab on 4th November for Rangoon where the field establishments were collected, and work was begun in the Bassein district on 17th November.

192. In Akyab, the cadastral survey has comprised the townships of Myohaung and Kaladan, east and west of the Kaladan river, and small portions of Urittaung and Minbya townships, the tract being divided into 134 villages and covering a total area of 349·66 square miles, distributed in about the usual proportion of cultivation and waste-land, as is shown in the following statement of the separate areas, *viz.* :—

	Square miles.
Cultivation	163·96
Jungle and waste	141·60
Rivers	44·10
TOTAL	349·66

The cultivated area includes 435,198 fields, of an average size of 0·22 of an acre.

193. In addition to the above, the boundaries of 10 Waste Land Grants lying in remote situations in the Naaf township have been revised, in consequence of changes which have been made subsequent to the survey of 1885-86. The maps of adjoining villages had also to be revised through these changes.

194. The topographical survey which has been executed in the Akyab district has been mainly restricted to the Mayu hill ranges in the Naaf and Rathedaung townships lying between cultivated valleys, and has been undertaken for the purpose of filling up gaps in the compiled topographical maps, which had been occasioned through the cadastral survey having been confined to the cultivated tracts. The scale adopted was that of 2 inches to the mile to correspond with the scale of the reduced compilations, and the survey that has been executed has enabled seventeen 2-inch standard size sections to be completed. In the case of the three Boronga islands situated to the extreme south of the district, the 1-inch scale has been adopted, the standard sheet in which they fall—sheet No. 47—comprising so small a portion of cadastral survey that there is no need for 2-inch sections to be projected. A small portion of the Kyaukpyu district, cutting into the Akyab district, was also surveyed topographically on the 2-inch scale to allow of the northern margin of Hunter's Bay being shown in the maps. The greater part of the topographical work is based on the traversing which had been used for the cadastral survey, but a small amount of triangulation has been executed for the survey of the Boronga islands. A special establishment had to be collected, mainly by transfers from parties in India, for this topographical survey. The areas which have been accomplished are as follows:—

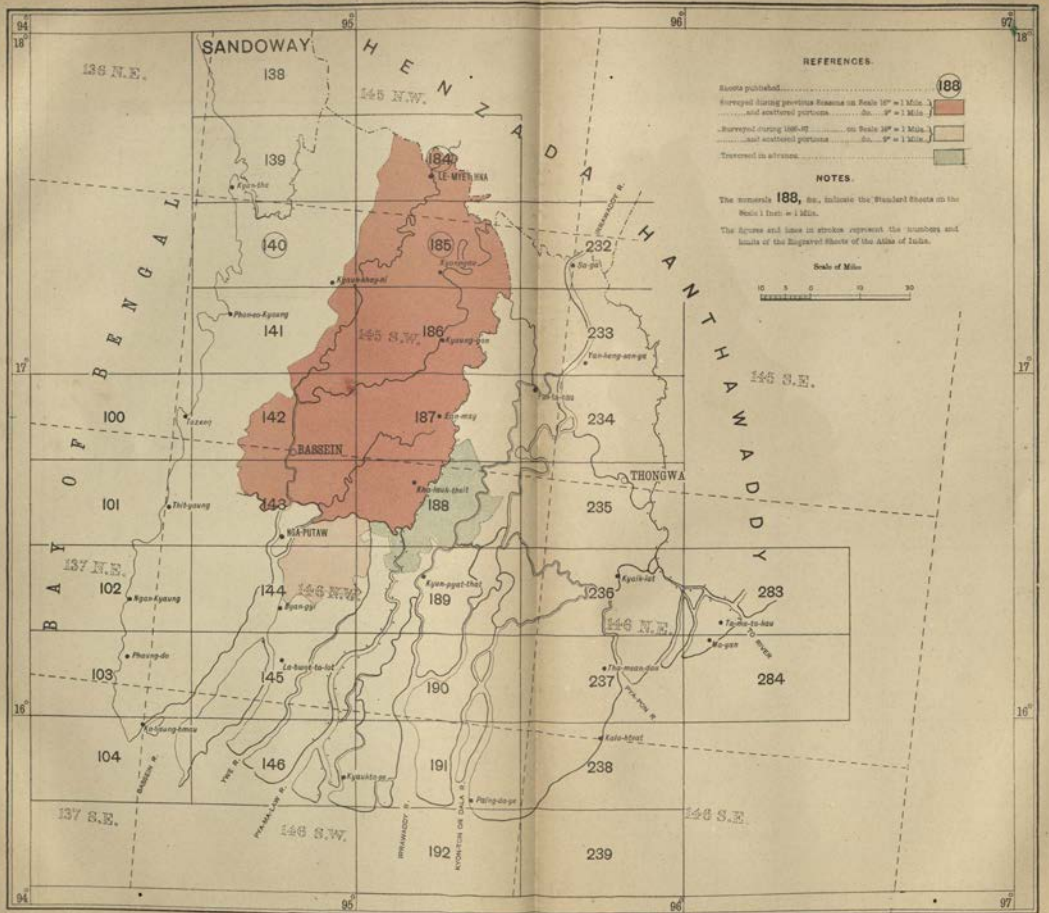
	Square miles.
District Akyab, scale, 2 inches to a mile	447
,, ,, ,, 1 inch to a mile	85
,, Kyaukpyu, scale 2 inches to a mile	60
TOTAL	592

195. In the Bassein district, three circles were assigned for cadastral survey, *viz.*, Pulu, Myaungmya and Labutkala, of which the two latter have been completed as regards the cadastral area, though a small area of hilly country in the Myaungmya circle remains to be surveyed topographically, while the Pulu circle has only been traversed. The completed area in circles Myaungmya and Labutkala is 228·07 square miles, 31·86 square miles being hilly country where the hilly features were sketched on the 2-inch, while the village boundaries,

LOWER BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. BASSEIN & THONGWA.

No. 7 PARTY



Published under the direction of Lieut.-Colonel H. H. Thuillier, R.E., Surveyor General of India.

Survey of India Office, Calcutta, October 1887.

Photozincographed at the Survey of India Office, Calcutta.

streams, and scattered cultivation were surveyed on the 16-inch scale. In the cultivated area there are 73,600 fields of an average size of ·67 of an acre, and the total area is distributed as follows:—

	Square miles.
Cultivation	85·98
Jungle and waste	92·74
River area	17·49
Hills	31·86
TOTAL	228·07

The area of Circle Pulu of Bassein, which remains to be cadastrally surveyed, is 75·59 square miles, and the area of four circles of the Thóngwa district which have been traversed is 258·32 square miles, giving a total of 333·91 square miles prepared in advance for next season's cadastral survey.

196. All theodolite traverse stations, of which there are 8,737, have been marked with pottery cylinders. Observations for azimuth have been taken at 81 stations, and the chain traverses have been connected with four stations of the Great Trigonometrical Survey. The detail survey in Bassein was tested by 270 linear miles of check surveys, of which 73 miles were measured by European Assistants and 197 miles by native Inspectors.

197. A scheme, proposed by the Administration of Burma and approved by the Government of India (Revenue and Agricultural Department letter No. 328 G.—96-5, dated 1st October 1886), with the object of attaching Burman surveyors more permanently to the Survey party than has hitherto been found to be practicable, has been adopted in the Bassein district with fair prospects that the scheme will prove a success, though the results cannot be ascertained from the working of one season. In previous years the difficulty experienced was not the entertainment of Burmans in the first instance, but the retaining of them afterwards, their main object in taking service being to acquire a knowledge of surveying and thus to secure a valuable qualification in their search for employment in other branches of the Government service. The chief feature in the present scheme is a system of crediting the surveyors with a certain amount of remuneration proportionate to their earnings, which amount will be deposited in the Savings Bank year by year, but will not be payable for five years, and only so if the recipient should serve continuously without a break and in whatever district to which he may be required to proceed with the Survey party. Only such surveyors as may gain, under a system of contract payments, more than ₹20 a month are entitled to the benefits of the scheme, and the amount of deferred pay to be credited to them is 20 per cent. of their earnings the first year and 10 per cent. in subsequent years. Besides the deferred pay, the surveyors will also receive as leave pay year by year on their return to duty from recess leave, a bonus proportionate to their earnings, according to the same system as has always been in force for the Hindustani surveyors. Under this scheme, 15 Burman surveyors have become entitled to deferred pay, and a total amount of ₹345, averaging ₹23 per man, has been drawn and deposited in the Savings Bank in their behalf. The Burmans, though not so quick as the Hindustanis, are trustworthy and accurate surveyors.

198. The cadastral area in Akyab has been mapped on 477 sheets, which will be retained in the party office pending the result of Settlement investigations. The sheets of the previous season, 1,024 in number, which had been retained for the same purpose, have all been sent to Calcutta to be printed without any revisions being called for. In Bassein, the number of cadastral survey sheets of the season is 267.

The area surveyed cadastrally and topographically in the Akyab district falls in 36 standard sections on the 2-inch scale, which are now in the course of being compiled and drawn in the office of the party. Standard sheet No. 47, which includes the Boronga islands, surveyed on the 1-inch scale, is being drawn on that scale.

199. The health of the party was on the whole good, except in the section employed on the topographical survey in the Naaf township of District Akyab, in which the daily average of sick throughout the season was 30 per cent. Among the establishment employed in Akyab there were 9 deaths, and 2 men were sent

home invalided. In Bassein and Thóngwa there were 6 deaths and 2 men were invalided.*

BENGAL AND ORISSA.

No. 8 PARTY.

200. On the abandonment of the cadastral survey of District Mozufferpore, which had constituted the work of this party during the previous season, the surveys of the Town of Calcutta and of the Wards' Estate of Sankarpur were assigned to be undertaken by two sections of the party, as mentioned in paragraph 207 of last year's Report, and to these separate works the survey of the Government estate of Angul was subsequently added (Government of India, Revenue and Agricultural Department, letter No. 916 S.—153-3, dated 22nd November 1886) to furnish employment for a third section. All the operations were placed under the supervision of Lieutenant-Colonel W. Barron, whose head-quarters were fixed in Calcutta, the officers selected for the charge of the detached sections being Mr. T. Shaw, for Sankarpur, and Mr. R. B. Smart, for Angul. Colonel Barron remained in charge up to 14th May 1887, when, on his being deputed by the Government of India to proceed to the Straits Settlements to advise the Government there on survey matters, in accordance with the application of that Government to the Government of India for the loan of an experienced officer, Mr. F. W. Kelly rejoining from medical leave, was placed in charge. Colonel Barron returned from the Straits Settlements and relieved Mr. Kelly on 30th August. Before proceeding on deputation, Colonel Barron visited the Sankarpur detachment twice, and the Angul detachment once. Mr. Kelly visited the Sankarpur detachment once; and Colonel Barron visited it again after his return from deputation. The section employed on the Calcutta Town survey began operations during the first week in November and continued at work up to 26th July. The section employed in the Sankarpur Estate began work in the Dinagepore district on 11th December 1886 and remained in the field until the end of June, when it proceeded to recess-quarters at Kurseong. The Angul section reached its ground, *viâ* Cuttack, on 11th January 1887 and continued its field work up to 15th June when it returned to Cuttack for recess.

Personnel.

Lieutenant-Colonel W. Barron, Deputy Superintendent, 2nd grade, in general charge to 14th May and from 30th August 1887.
Mr. F. W. Kelly, Officiating Deputy Superintendent, 4th grade, in general charge from 15th May to 29th August 1887.

Calcutta Section.

Mr. D. Atkinson, Surveyor, 1st grade, to 31st October 1886, and from 27th December 1886.
Mr. A. B. Smart, Assistant Surveyor, 3rd grade.
11 Draftsmen and Computers.
29 detail Surveyors.

Sankarpur Section.

Mr. T. Shaw, Assistant Surveyor, 1st grade.
„ C. G. Lee, Assistant Surveyor, 3rd grade.
„ C. H. Milner, Assistant Surveyor, 3rd grade, from 2nd October 1886 to 12th September 1887.
13 Sub-Surveyors and others.
173 Temporary Surveyors, Draftsmen and Computers.

Angul Section.

Mr. R. B. Smart, Surveyor, 4th grade.
„ R. C. D. Ewing, Assistant Surveyor, 1st grade, from 12th September 1887.
Mr. J. A. Higgs, Assistant Surveyor, 2nd grade, from 28th December 1886.
19 Sub-Surveyors and others.
66 Temporary Surveyors and others.

Survey of the Town of Calcutta.

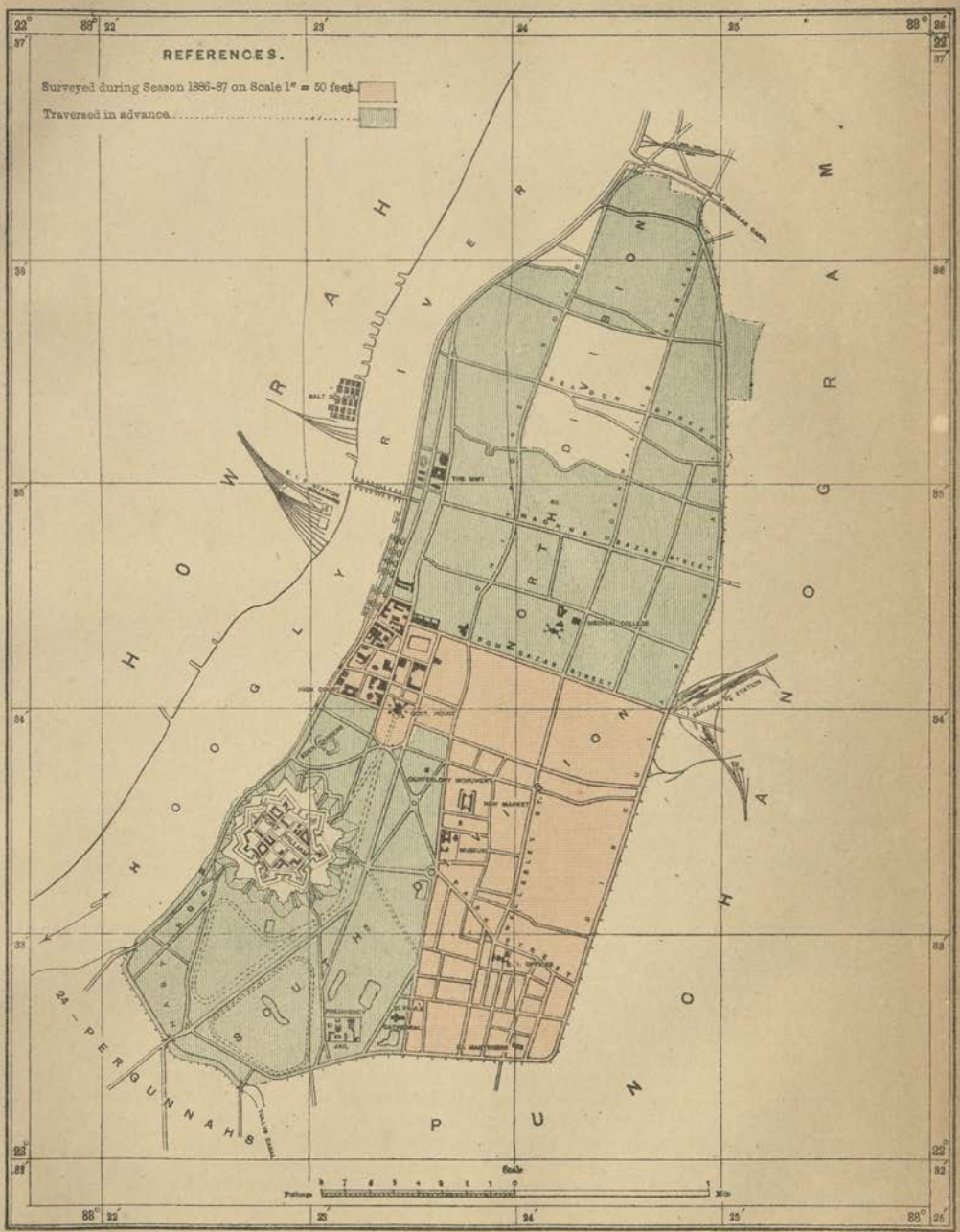
201. The first action towards the present re-survey of Calcutta was taken by the Corporation of the Town, whose desire to have the town re-surveyed, both on account of the plans of the former survey of 1847 having become out of date through the many changes that had occurred, and on account of the survey having been on too small a scale, was intimated to the Government of India in letter No. 1835T.-R., dated 11th September 1884, from the Under-Secretary to the Government of Bengal, Land Revenue Department. The Govern-

* Colonel Hutchinson has recorded the high opinion he has of Mr. H. R. Littlewood as a surveyor, and he has represented that the duties of Mr. Littlewood in the Bassein district during his absence in Akyab were of an unusually responsible nature.
Mr. Jarbo is especially mentioned for very hard work while in charge of the traverse section. Mr. Swiney is said to have supervised a cadastral section with excellent results. Messrs. Barker and Beechey are well reported on.
The undermentioned members of the native establishment are reported on favourably, *viz.*:—
Moung Hpo Kah, Ishan Chunder Ghosal, Shoshi Bhusan, Prionath, Azimulla, Mohamed Hossein, Ikbaludin and Manaur Ali.

BENGAL SURVEY.

INDEX TO THE SURVEY OF THE TOWN OF CALCUTTA.

No. 8 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel H.R.Thuillier, R.E., *Surveyor General of India.*

Survey of India Offices, Calcutta, January

1888

ment of India expressed willingness to the proposed survey being assigned to the Survey of India, but at the time was unable to detach a party for the purpose. The matter was held in abeyance until a section of the Mozufferpore Party became available, and the survey was finally ordered in Government of India, Revenue and Agricultural Department, letter No. 757S.—140-2, dated 3rd September 1886. In the meantime, with the survey in contemplation, several matters connected with it had been considered by the Government of Bengal.—A proposal to extend the survey to the suburbs was discussed and for the time abandoned: a Committee was ordered to assemble under the direction of the Board of Revenue to report specially on what might be required regarding the demarcation of holdings and concerning the register of holdings that might be found to be necessary: and the need for a special Act to legalize the survey was ascertained through a reference to the Advocate General who held that the Bengal Survey Act of 1875 was not applicable to the Town of Calcutta.

202. The "Calcutta Survey Act, 1887," received the assent of His Honour the Lieutenant-Governor of Bengal on 15th January 1887, and of His Excellency the Viceroy on 31st idem. In it, the Deputy Superintendent in charge is appointed Superintendent of the Survey and is authorized himself, or others deputed by him, to enter on any land or premises for the purpose of survey either with the consent of the occupier or by giving twenty-four hours' notice. He is also authorized to inquire into the boundaries of holdings by giving three days' notice to the owners to appear and point out their boundaries. In cases of dispute the matter is to be settled by an Assistant Superintendent of Survey who will be a judicial officer and from whose decision an appeal may be made to the Board of Revenue. When the dispute is decided, the Superintendent is authorized to lay down the boundaries in accordance with the award. He may also cause the erection of any boundary-marks he may think necessary on any land which is to be or has been surveyed under this Act. The Act provides that after the survey of any part of the town has been completed, the maps and all other documents connected with the survey shall be deposited for inspection by the public for two months in the Municipal Office of the Corporation of Calcutta, the date of deposit being notified in the *Calcutta Gazette*. After any objections lodged within that time have been decided, the Local Government shall signify its approval of the survey by notification in the *Calcutta Gazette*, and no suit to set aside any demarcation of boundaries made under this Act shall lie unless brought within one year from the date of this notification.

203. The previous survey of Calcutta, which was executed from 1847 to 1849 by Mr. F. W. Simms, C.E., was in itself a plain topographical survey, on the scale of 100 feet to the inch, of streets and buildings, but to it was added a survey of the boundaries of holdings carried out by Mr. W. Heysham, Deputy Collector, whose investigations and operations extended from 1851 to 1855 and who converted Mr. Simms's topographical maps into maps showing the holdings with index numbers referring to a register of owners and of areas. These maps of Mr. Heysham's would, it was pointed out by the Committee referred to above which reported to the Board of Revenue, furnish guides to the identification, or demarcation, if necessary, of the holdings as formerly existing, but it was stated that many holdings had been subdivided and some had been amalgamated with others. The old holdings would all have to be searched out and the changes by subdivision would have to be mapped by the new survey. The Committee reported that Mr. Heysham's original registers, though still available with the Collector of Calcutta, had become useless through the changes in proprietorship not having been written up, but a new set of registers which had been begun in 1877 under the provisions of the Land Registration Act of 1876 were said to have recently undergone a thorough revision and were believed to be such as would render the preparation of a new register during the present survey quite unnecessary. The scale of 50 feet to an inch for the new survey was proposed and agreed to.

204. The survey was begun in the European quarter and has been completed throughout the whole of the southern division of the town, that is, as far north as Bowbazar, covering an area of 1,431 acres, or 2·23 square miles; but the field work only has been completed and the drawing of the final maps still remains to be done. All surface features have been shown with the greatest minuteness, the scale admitting of the plotting of measurements as low as 1 foot, while the traverse

measurements on which the skeleton basis of the field sheets has been projected have been recorded to the nearest tenth of a foot. The underground lines of sewers, gas and water-pipes, which the municipality require to be shown, will be added afterwards.

205. In surveying the boundaries of holdings, Mr. Simms's plans as amended by Mr. Heysham were found to be excellent guides, but the boundaries on those plans which are on the scale of 100 feet to the inch, are not shown with the minuteness now practicable by the present survey on double the scale, and the exact line of each boundary has been carefully inquired into in the presence of adjoining proprietors or their agents. The disputes regarding boundaries which have been met with mostly concern the proprietorship of boundary walls or drains and a few have reference to small pieces of ground adjoining lanes. In the southern division of the town, there are in all about 4,315 holdings, of which, up to 30th September 1887, the boundaries of 2,727 had been investigated, with the result that only 106 disputed portions remained for judicial disposal.

206. Throughout the town there is not much need for special demarcation of boundaries, as most of the holdings are divided off by masonry walls. Where these do not exist, and where the Corporation is interested, the demarcation has been effected either with rows of bricks on end or with stone pillars. Where such marks are wanting between private holdings, the proprietors have been warned to erect them.

207. The numbering of the holdings is the same as was adopted for Mr. Heysham's plans and registers, the numbers (which are in separate series according to Simms's survey blocks) having been brought into general use in the town in matters connected with the transfer of properties and payment of ground rents and thus obviously rendering their retention most desirable. An attempt was made to use the newly written registers in issuing notices to the proprietors to attend at the investigation of the boundaries, but these records were found to be of little or no value for this purpose, the changes of names not having been kept up as had been expected. A house-to-house visitation was then instituted to ascertain the names and addresses of owners by inquiry from the occupants, and in this way the issue of notices has been effected. A survey register of the owners is being kept, which will be available for the correction of the Collector's registers.

208. As a skeleton basis on which to plot the measurements of the details, the town has first been subdivided by theodolite traverses into sections averaging in size 3·8 acres, which again are further subdivided by lines measured to convenient points which can be fixed by two or more direct measurements. Other direct lines are run inside these and the work is thus cut up into small portions inside which the topography is surveyed by means of offsets. In the case of native houses it is often necessary to take the chain lines through the house for the purpose of surveying the inner open spaces. It may be mentioned that very little opposition has been given to the survey, and in most cases a little explanation removed it. Also, it says well both for the surveyors and the occupiers that the work has been carried on even to surveying the open spaces belonging to the parts of the house set apart for females without any trouble worth mentioning. At first there was some trouble in getting the owners to attend to point out their boundaries, but now when the objects of the survey have become better known they attend readily.

209. A very severe check was exercised over the survey of the details by the Deputy Superintendent and his European Assistants and everything is said to have been entered with the greatest accuracy. The boundaries of the holdings are all investigated by the European Assistants. For convenience of survey, the field plans have been projected in portions generally bounded by streets and they are being inked up and coloured to distinguish the masonry from the temporary structures. The final maps, which will be drawn in a suitable style for reproduction by photozincography, will be projected of a larger and more uniform size than the field plans.

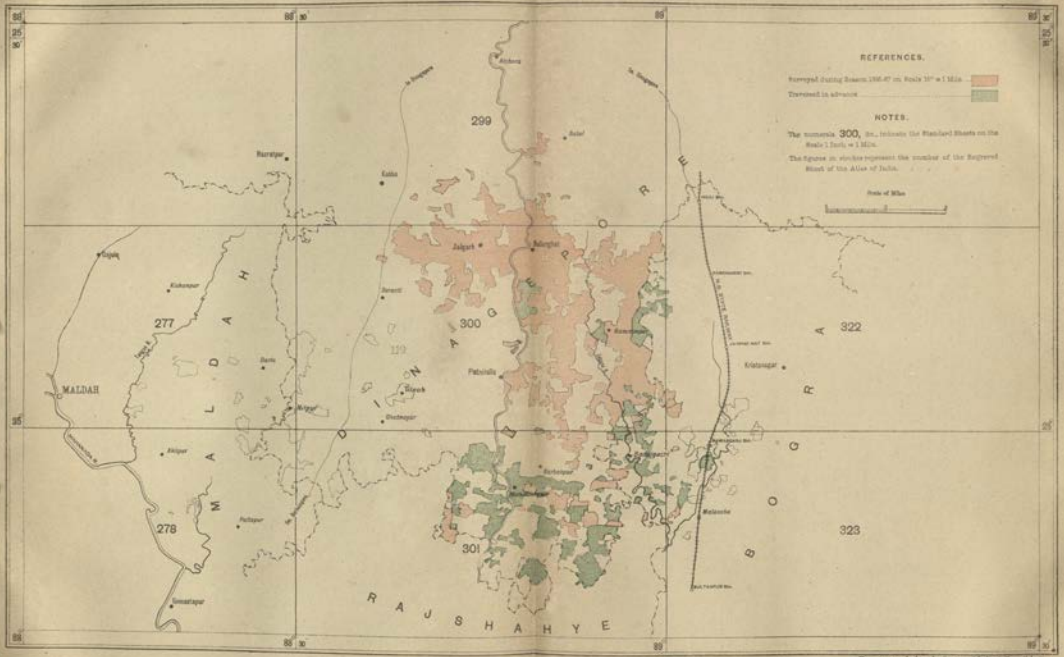
Survey of the Ward's Estate of Sankarpur.

210. The cadastral survey of this estate was applied for in behalf of the ward by the Collector of Dinagepore, acting under the instructions of the Board of

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE SANKARPUR ESTATE.

No. 8 PARTY



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Survey of India Office, Calcutta, October
1907.

Photozincographed at the Survey of India Office, Calcutta.

Revenue, in terms of section 101 (2) (a) of the Bengal Tenancy Act VIII of 1885, the provisions of the section permitting the application to be made, as the minor whose estate is being managed by the Court of Wards, although not the sole proprietor, holds the requisite 8-anna share in a large portion of the estate where there is only one other co-sharer who has joined in the application for the survey. The co-sharers in the other portions of the estate were expected to join in the application for the survey, and at first they gave a partial consent, but finally they all withdrew, and the entire expense of that portion of the survey will be borne by the ward. The estate is not situated in one compact tract, but lies in blocks of villages, and in single villages, over the districts of Dinagepore, Bogra, Rájsháhi and Maldah, the larger portion being in the first-named district. In area, the summation of the lands of the estate equals about 270 square miles, yet the lands are scattered over an area of about 1,200 square miles.

211. Besides the villages in which the estate is interested being much scattered, the condition of the estate is still further complicated through the lands in some villages, mainly so in two *parganas*, being interlaced with the lands of other estates. These interlaced lands were necessarily obliged to be surveyed along with the estate lands, as without doing so the maps would have formed a very indistinct record of the positions of the detached portions of the estate; besides, without enquiry being made regarding the proprietorship of each separate plot of land after all had been surveyed, there would have been no certainty that the register of the estate lands was complete. Considerable opposition was offered by the proprietors of the interlaced lands to the survey being made in this comprehensive manner, but it was overcome after full explanation had been given of the scope of the survey by the Manager of the Sankarpur Estate.

212. As far as the survey has yet progressed it has been possible to include the villages within main traverse lines, so that the relative positions of the blocks of villages or of single villages can be accurately mapped, but some villages remaining for survey are so far outlying that they will have to be surveyed on independent traverses of their own. The traverse survey has been completed of 673 villages containing an area of 245 square miles, and of these 532 villages have been cadastrally surveyed with an area of 198·64 square miles and containing 124,833 "fields," the scale of survey being the usual cadastral scale of 16 inches to a mile. The village records have been completed for 470 villages containing 93,466 "fields." In the greater portion of the surveyed area the *khasra* writing was simple, the village lands being held in common by the two shareholders, but in the two *parganas* where there are interlaced estates the writing was more difficult. The cadastral survey has been carried out by trained *amins* brought down from the North-West Provinces and from Behar, but locally entertained writers had to be attached to the *amins* to assist in preparing the *khasras* which the up-country *amins*, being unacquainted with Bengali were unable to write for themselves.

213. The demarcation of the boundaries, which is according to present possession, has been effected by the officials of the estate working under the Manager, which ought to be sufficient guarantee that the interests of the estate in this matter have been well guarded, but in many instances the present boundaries are found to disagree very much from the former village survey of 1857—60. Formerly there had been no permanent demarcation; now, the tri-junctions have been marked with stone prisms, and other selected points on the boundaries where theodolite stations have been fixed are marked with pottery cylinders.

214. Soon after the survey of the estate was begun, a Settlement Officer, Babu Sasi Bhusan Datt, was appointed who in the first instance was occupied in settling village boundary disputes, of which there were 41, and to whom subsequently traces of the cadastral maps and the village *khasras* and other records (as soon as they could be completed by the addition of the areas of fields) were sent for final inquiries regarding rents and the status of the tenants.

215. At the latter end of March the country became very unhealthy owing to the drying up of the innumerable tanks and marshes. Sickness spread rapidly among the survey establishment, scarcely a man was free either from fever or dysentery, and the survey camp became one large hospital. During April, the sickness abated and part of the establishment was able to resume work, with which and with some additional men got down from the North-West Provinces

an attempt was made to complete the survey of the estate by continuing the work late into the season, but when the rains set in the attempt had to be given up. An area of about 71 square miles has thus been left for next year.

216. Mr. Shaw writes in the following terms of the assistance he received from Mr. Ricketts, the Manager of the Sankarpur Estate, *viz.*,—

"The detachment is much indebted to Mr. Ricketts for his continual efforts to facilitate the work. His success in inducing the *raiyats* to supply the *amins* with voluntary labour has saved the estate a large sum. Mr. Ricketts's endeavours to get the proprietors of interlaced estates to join in an application for survey and to share expenses, although not crowned with the success they deserved, had the effect of stopping opposition to the surveyors, and so decreasing the cost of the work."

217. Towards the end of the field season, intimation was received that the Ward's Estate of Maldwar situated in the Dinagepore and Purneah districts was required to be surveyed cadastrally during the following season. Preliminary traversing was therefore undertaken in part of the estate in the Dinagepore district and has been completed for an area of 50 square miles. During September, a survey school was established for the *patwáris* of the Maldwar Estate under a scheme by which these officials would be employed on the cadastral survey, but the attendance has not been satisfactory.

Survey of the Estate of Angul, Orissa.

218. Killa Angul, formerly a tributary *mahál*, was confiscated in 1847 on account of the rebellion of the Rajah then in possession, and is now a Government estate. It was surveyed topographically on the one-inch scale in 1853-54 during the course of the operations of the Ganjam and Orissa topographical survey. Its present cadastral survey has been undertaken for the purposes of a revision of the settlement, the existing settlement, made without a complete survey of fields, having expired on 10th September 1887.

219. There having been no previous regular demarcation of village boundaries, and the exterior boundary of the Killa never having been accurately defined, a demarcation party under Babu Bisesur Banerjee was sent by the Board of Revenue about one month in advance of the survey to prepare the ground in this respect, and except as regards the exterior boundary, where there was delay on account of many parts being contested, the boundaries had been marked (though with temporary materials only) to allow of the survey work progressing without hindrance. This demarcation party was soon afterwards broken up, the demarcation of the part of the Killa left undone having been assigned to the *tahsildár*, the resident official in charge of the revenue and judicial functions. The *tahsildár* was also appointed to be a Settlement Officer and in association with him, Mr. A. K. Roy, a Government student from the Cirencester Agricultural College, was appointed to be a Joint Settlement Officer.

220. The survey work having been undertaken late in the season (the detachment reached Angul on 11th January 1887), the programme for the year was that the operations were to be restricted mainly to village boundary traversing, but a cadastral survey was to be initiated, and such an area completed cadastrally as a new establishment of local *amins* might be capable of accomplishing after having been trained. The traversing has been completed for 386 villages covering an area of 354 square miles, of which 83 villages, in area 61 square miles, have been surveyed cadastrally on the 16-inch scale, leaving 303 villages containing 293 square miles prepared for next season's survey. The remaining area of the Killa yet untouched includes about 336 square miles of village lands and 205 square miles of reserved forests.

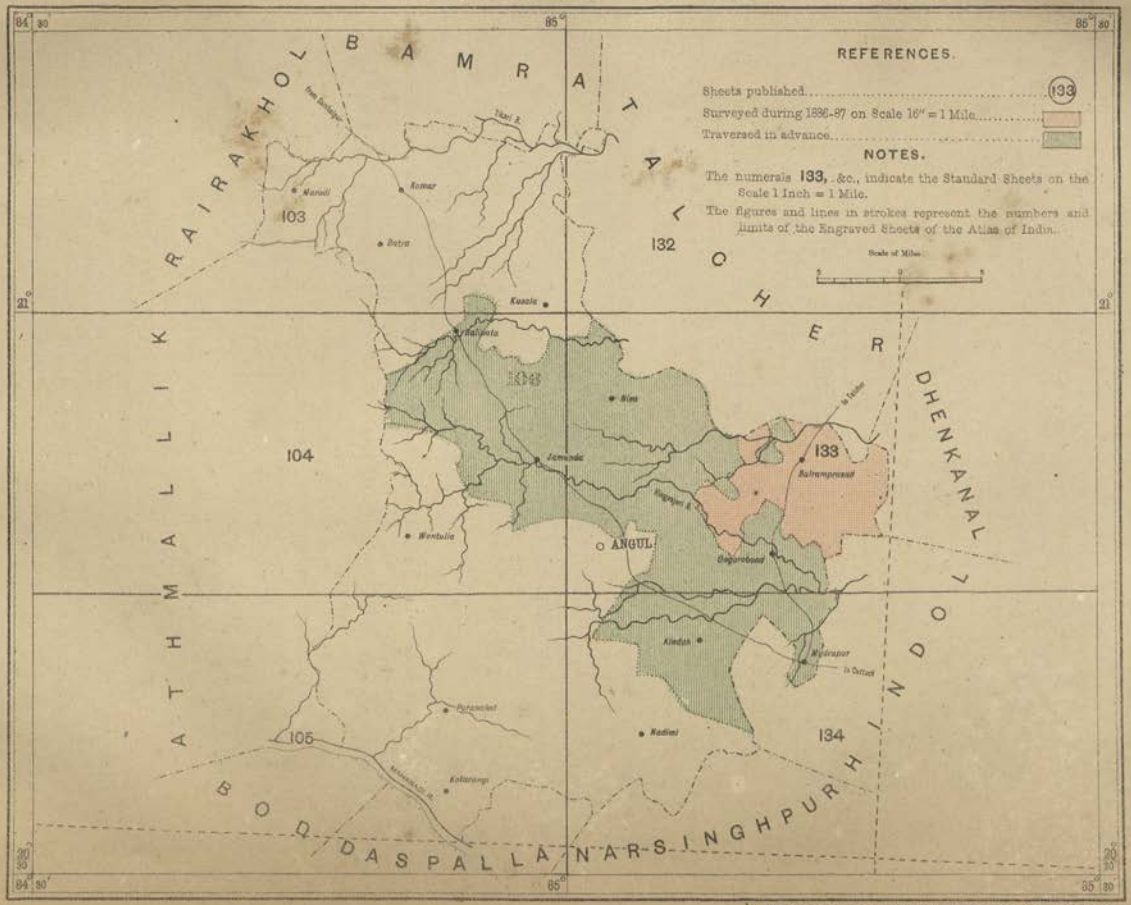
221. The writing of the *khasras* and other vernacular village records has been facilitated by the exclusive employment of natives of Orissa as cadastral survey *amins*, the records being required to be written in the Ooriya character; but there has been considerable difficulty in filling up the records as regards the status of the tenants whose claims to occupancy rights are disputed by the *sarbarákárs* (or village headmen); and in the matter of classification of soils, the distinctions of which could not be readily recognised, there has also been difficulty.

222. As regards the permanent demarcation of boundaries, the marks which have yet been put down consist only of pottery cylinders at theodolite stations,

ORISSA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE ANGUL GOVT. ESTATE

No 8 PARTY



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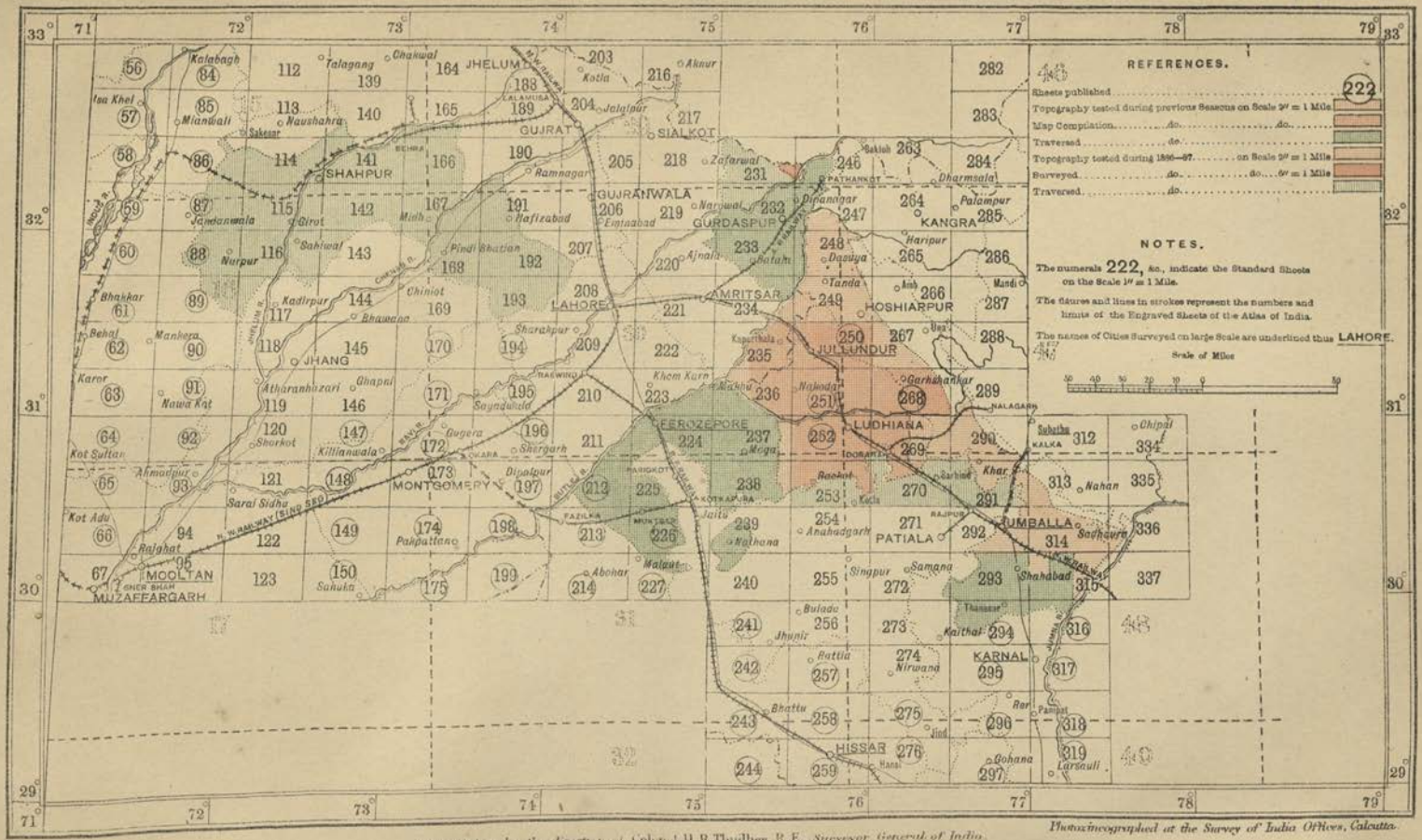
Survey of India Offices, Calcutta, October.

1887

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE PUNJAB.

No. 1 PARTY.



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Survey of India Offices, Calcutta, January.

1868

Photozincographed at the Survey of India Offices, Calcutta.

but the tri-junctions of village boundaries in the interior of the Killa are about to be marked with masonry platforms, and similar marks will eventually be placed at intervals of a quarter of a mile along the exterior boundary after the boundary has been finally confirmed by the Government of Bengal.

223. In accordance with the policy enjoined by the Government of India that all cadastral surveys should, if possible, be executed by village officials who are remunerated for the maintenance of village records, the Government of Bengal, acting on information received after the survey had been begun, directed that the *sarbarákárs* (who receive a large percentage for collecting the village assessments) shall be required to qualify as surveyors, so that they may be exclusively employed during next season in executing the survey. Survey schools for the *sarbarákárs* were therefore commenced during May, experienced surveyors who had served with cadastral surveys in the North-West Provinces having been sent for to act as instructors; and when the survey party retired to Cuttack for recess in June the schools were left in charge of the Joint Settlement Officers who continued to reside at Angul. The undertaking is an extensive one on account of the very large number of individuals who have *sarbarákári* rights; but as these rights in some cases extend only to a very few acres, all the individuals possessing them may not have to be employed as surveyors. Up to September, 304 *sarbarákárs* or their nominees had been taken under instruction, and it is believed that about 200 more will have to be taught.

A survey school was also begun during August for the *sarbarákárs* of the Government estate of Banki attached to the Cuttack district, the cadastral survey of which will be undertaken next field season.*

TRAVERSE SURVEYS.

PUNJAB PROVINCE.

No. 1 Party.

224. This party, having closed its recess office at Simla on 13th October 1886, was, on its return to the plains and on the establishment being raised to field strength, sent to the localities for field operations in two sections, which were respectively organized in accordance with the nature of the work each had to perform. One section proceeded to the Gurdáspur district, the completion of the traversing of which was its first duty, and afterwards it had to undertake the testing of the topography obtained from the settlement survey maps of the Hoshiárpur and Umballa districts. The field work of this section was begun on 1st November and was continued up to 10th May 1887. The second section, whose field season extended from 26th October to 15th May, proceeded first to the Gujránwálla district and afterwards to the Shahpur district, in both of which it had to do traversing work only.

Personnel.

Col. F. Coddington, S.C., Deputy Superintendent, 1st grade, in charge.
Mr. J. S. Pemberton, Surveyor, 2nd grade.
" C. W. Wilson, Assistant Surveyor, 1st grade.
" G. Campbell, Assistant Surveyor, 1st "
" F. P. Walsh, Assistant Surveyor, 3rd "
" F. S. Bell, Assistant Surveyor, 3rd " from 21st October 1886.
31 Sub-Surveyors and others.

* Colonel Barron reports as follows concerning the services of his assistants employed on the several operations, *viz.*,—

"Mr. D. Atkinson who had charge of the Calcutta survey has worked well and has taken great trouble in testing the accuracy of the work and inquiring into the boundaries of the holdings of which he has personally investigated 2,525.

"The report on the survey of the Sankarpur estate has been compiled from notes supplied by Mr. Shaw in charge of the detachment, and the Deputy Superintendent desires to bring to favourable notice the services of Mr. Shaw during a very trying season and under circumstances of sickness and opposition that made his charge a very difficult one.

"Mr. R. B. Smart has been in charge of the Angul detachment throughout the season. He took the detachment to Angul and started the work, and the Deputy Superintendent would bring to notice his energy in giving the out-turn he has done when he only commenced about the middle of January and had to train most of the men who did the interior work. The report on the Angul survey has been compiled from notes supplied by Mr. Smart."

The services of Messrs. A. B. Smart and C. G. Lee are favourably mentioned. Messrs. J. A. Higgs and C. H. Milner are said to have suffered much from fever during the field season.

The names of the members of the native establishment who are well reported on are:—Shaikh Abdullah, Wazir Ali, Gyasi Ram, Manohar Lall, Shamshudin, Abdul Jalil, Raghubír Saran, Janki Pershad, Murli Dhar, Rahim Bakhsh and Ganga Bishen.

225. The several operations on which the party is engaged, and which have already been described at paragraph 226 of last Report, may be again mentioned for convenience of reference; they are:—

(1) The skeleton traversing of villages for the purpose of determining the co-ordinate distances of tri-junction points; and the projection of maps of the tri-junctions on the scale of 2 inches to the mile.
(2) The insertion of topographical details on these maps by reduction from the Settlement survey village maps.
(3) The testing and correcting (where necessary) the reduced maps by examination in the field.
(4) The drawing of fair maps on the 2-inch scale.
(5) The re-drawing of the old 1-inch maps of the Sikh States to complete the portions of these territories falling within the present continuous series of maps of standard size. (This is a new work undertaken this season.)

The areas accomplished during the season under these separate heads in the several districts are as shown below:—

Districts.	(1) Area traversed.	(2) Area mapped by reduction (2-inch scale).	(3) Area tested (2-inch scale).	(4) Area finally mapped (2-inch scale).	(5) Area redrawn (1-inch scale).
	Square Miles.	Square Miles.	Square Miles.	Square Miles.	Square Miles.
Ferozepore	...	1,150	...	...	...
Gujránwálla	1,360	...	...	...	...
Gurdáspur	575	...	...	...	...
Hoshiárpur	...	482	940	951	...
Kapurthala (State)	...	...	...	78	...
Jullundur	...	...	...	56	...
Ludhiána	...	...	...	45	...
Shahpur	4,150	...	...	...	...
Sikh States	...	...	...	38	640
Umballa	...	1,872	1,738	1,558	...
Total	6,085	3,504	2,678	2,726	640

The operations under head (1) have been completed in Gurdáspur; also, in Shahpur as far as they are required, the Salt Range having been excluded from the survey. The operations under the same head in Gujránwalla were restricted to the Háfizabad *tahsil* where they were required by the Irrigation Department to assist the laying out of canals. In the rest of the district, the operations may be deferred for a few years until the time for the re-settlement approaches. Under head (2), the area which has been mapped in the Ferozepore district is of the Muktsar *tahsil*, for which village maps of the last settlement were available, a new settlement being not at present contemplated for that *tahsil*. The mapping of the remaining *tahsils* will be undertaken when the settlement survey now in progress is completed. Under the same head, the mapping in Districts Hoshiárpur and Umballa has been completed, that is, for the plains portions of these districts for which portions only the Settlement Survey maps will be utilized; the hilly parts of the districts will be surveyed independently by the Himalaya Party. Under head (3), the testing has been finished of the Hoshiárpur district, but 825 square miles remain over for next season in Umballa. As heretofore, the topography obtained from the Settlement Survey maps has been proved by the testing to be satisfactory, needing only to be supplemented in such items as the high banks of rivers, limits of village sites, bridges, and mile-stones. Under head (4), the final mapping of the plains portions of sheets 266, 267, 289, 290, 291, 313, 314, and 336 has been done as far as possible, but the hill portions remain to be added by the Himalaya Party before the sheets can be published. In sheet 269 there are two detached

portions of the Patiála State, the topography of which has been obtained from actual survey, and the 2-inch sections of the sheet have thus been rendered complete and ready for publication on the 1-inch scale. Village boundaries have been inserted in these detached portions by transfer from an Irrigation Survey map which was available. Sheet 270 contains a limited extent of revenue-paying territory, the main portion consisting of parts of the Patiála and Nabha States. The 2-inch sections of this sheet, which are confined to the revenue-paying area, with a small tract added for which irrigation maps were available, are therefore partial only. For the incomplete portions of this sheet, as well as of all other sheets of the new standard series similarly constituted (a proposal for a new survey of the Sikh States having been for the present negatived), it has been decided to introduce the topography of the 1-inch survey of the Sikh States which took place in 1847-50. Thus, the portions of Patiála and Nabha falling in sheet 270 have been re-drawn from the old maps, but the style of drawing is different from that adopted for the revenue-paying portions, so that the less reliable topography is readily distinguishable. Similarly, for the portions of the Sikh States falling in sheet 253, the revenue-paying portion of which had been mapped during the previous season, a drawing from the old maps of 1847-49 has been made to allow of the sheet being published with all the available topography. A small amount of new traversing has been necessary to enable the irrigation surveys to be incorporated into sheet 269, and a little new traversing has also been required for the introduction of the old surveys of the States into sheets 253 and 270.

226. At the request of the Financial Commissioner of the Punjab, a special survey on the 6-inch scale has been executed of 45 square miles of somewhat intricate country adjoining the Ravi river in the Gurdáspur district along the boundary of Kashmir territory. The object of the survey is to facilitate the adjustment of a dispute of long standing between the British and Kashmir cultivators as regards the rights to water from irrigation channels that take off in Kashmir territory, a proper investigation as to the rights, or clear representation of the facts in the report of the Settlement Officer having been found to be impracticable without a map. The survey in Kashmir territory is a skeleton survey of the water channels only, which has been effected by theodolite and chain traversing with the measurements recorded in field books, the local officials having objected to anything like a map being made on the spot without more specific orders than they had received from their State authorities. The information that has been obtained in this way was expected to be sufficient for the purpose of the survey, but the Government of the Punjab has since made a requisition for a survey of the Kashmir lands the same as of the adjoining lands in Gurdáspur. Tracings of the maps of the entire tract have been furnished to the Settlement Officer of Gurdáspur, who has expressed his approval of them and stated that they have enabled him to send in a preliminary report.

227. In accordance with the request of the Financial Commissioner, Sub-Surveyor Eed Mahomed was detached to serve under a Civil officer who had been specially deputed to carry on an inquiry into certain disputes which had arisen on the boundary between District Dera Gházi Khán and the Baháwalpur State consequent on changes in the bed of the River Indus. The duty required of the Sub-Surveyor, who was detached for four months, consisted mainly in relaying old boundaries, which work is said by the Civil officer under whom the Sub-Surveyor served, to have been done to his entire satisfaction. A portion of the boundary between Sind and the Punjab was also revised by the Sub-Surveyor as part of the same operations.

228. In the recess office, under arrangements made on the requisition of the Financial Commissioner, the plotting has been executed of the village boundary traverses and other special traverses done during the topographical survey of the Hissar district—seasons 1882-83-84,—in preparation for the field survey by *patwáris*. The skeleton sheets, which are on one or other of the Provincial scales of 27·7 or 13·8 inches to the mile, according to lists furnished by the Settlement authorities, and which amount in number to 4,599, have all been made over to the Deputy Commissioner of Hissar.

229. The Surveyor General inspected the recess office of the party at Simla in October 1887, and was highly satisfied with the state of the records and maps which were found to have been carefully prepared and completed up to date.

The general efficiency of the party under Colonel Coddington's able management has been fully maintained.*

RAIPUR DISTRICT, CENTRAL PROVINCES.

No. 3 Party.

230. This party returned from its recess quarters at Mussooree and resumed its operations in the Raipur district on 1st November, which was a fortnight earlier than the party took the field the previous season. On the other hand, the work was stopped on the 1st May, also a fortnight earlier, the experience of the previous season having shown that very little work can be got out of a survey establishment in that part of the Central Provinces during the great heat of May. The office establishment then returned to Mussooree for recess.

Personnel.

Lieutenant-Colonel W. H. Wilkins, Deputy Superintendent, 2nd grade, in charge.
Mr. W. S. Buttress, Surveyor, 2nd grade.
„ A. Christie, Surveyor, 3rd grade, on furlough from 18th November 1886 to 15th May 1887.
Mr. C. Tapsell, Surveyor, 4th grade, from 1st November 1886.
Mr. G. Vanderbeek, Assistant Surveyor, 1st grade.
Mr. T. W. Babonau (Jr.) Assistant Surveyor, 3rd grade, up to 30th April 1887.
44 Sub-Surveyors and others.

231. The nature of the operations is the same as were initiated the previous season in aid of the settlement survey of fields by *patwáris*, being purely skeleton traversing of village boundaries and such amount of subordinate traversing in large villages as may be required to furnish a proper basis for the chain measurements of the *patwáris*. Part of the area of the present season, and part of the area traversed during the previous season, in all 565 square miles, have, however, been made over for cadastral survey to the Bilaspur Party, a portion of the establishment of that party having been removed from the Bilaspur district on account of the partial failure of the autumn harvest.

232. All traverse stations are required, under the sanctioned scheme for the Central Provinces traverse surveys, to be marked permanently with stones, and in some of the districts under survey these stones have to be provided and transported at a large expense, but in Raipur most of the salient points of village boundaries are marked with stones, and expense has been saved by adopting these points as traverse stations.

233. The country surveyed lies in the north-west and south-west parts of the district; it consists of portions of Tahsils Simga, Dhamtari, Drug and Raipur, and of Pargana Sahawa, an old *zamindári*, and covers a total area of 3,150 square miles. Pargana Khalári in the south-east of the district, which had been excluded from the contiguous survey of the previous season through misapprehension of the need for its being surveyed at all, it having formerly been a *zamindári*, was made over for survey, on account of the convenience of its position, to the Bilaspur Party, by which it has been traversed for the settlement survey.†

234. The area surveyed being so large—981 square miles more than the out-turn of last season—the office computations connected with it have not been fully brought up during the recess, and they will be carried on by an increased office establishment during next field season. About two-thirds of the computations had been finished at the end of the recess season.

235. The out-turn of the season has been effected by means of 7,509 linear miles of traversing and by theodolites being set up at 29,030 stations. Observations for azimuth were taken at 174 stations. No Great Trigonometrical Survey stations were met with, but connections were made on 7 triangulation points of the Ganjam and Orissa topographical survey.

236. At the request of the Commissioner of Settlements and Agriculture, Central Provinces, the area remaining to be traversed for the settlement survey of Raipur—about 900 square miles—will be made over for execution by the

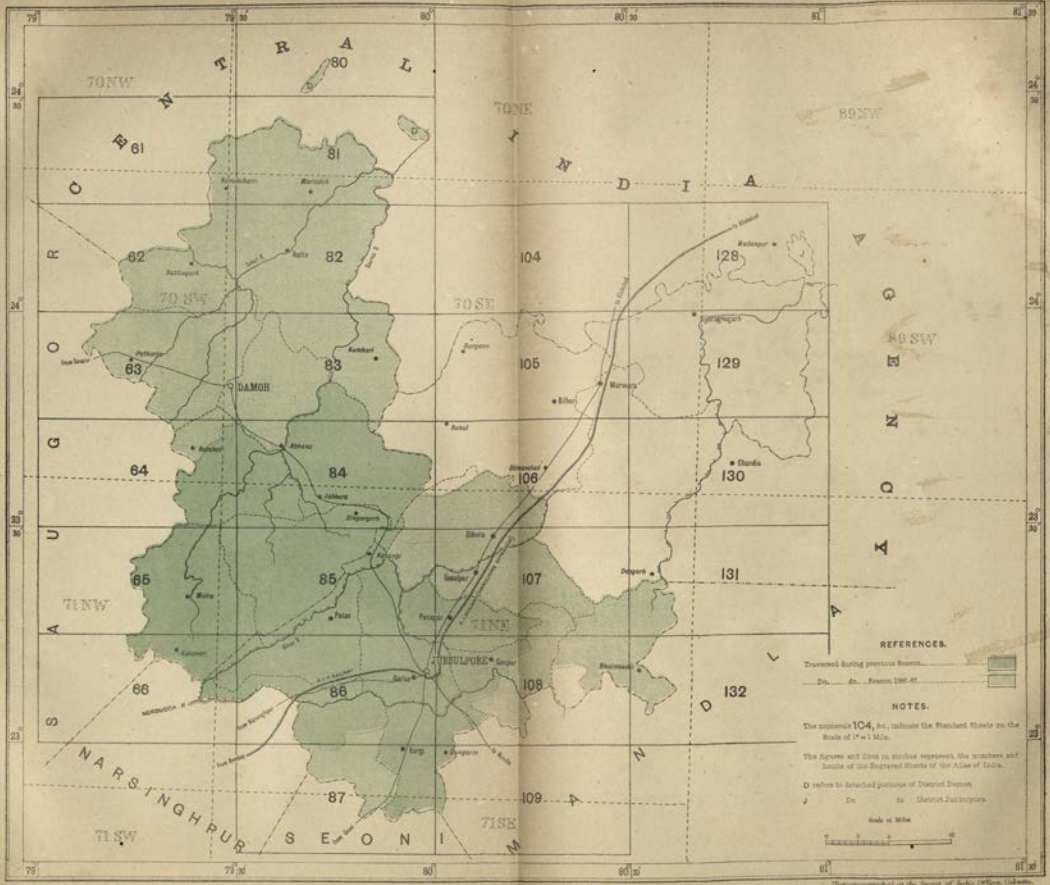
* Colonel Coddington writes very favourably of the services of Messrs. J. S. Pemberton and C. W. Wilson who were in charge of sections, and reports that Messrs. G. Campbell, F. P. Walsh, and F. S. Bell have also given satisfaction in the respective work for which each of them is qualified. The undermentioned Sub-Surveyors are said to deserve mention for the efficient way in which they have performed their respective duties, *viz.*, Eed Mahomed, Elahi Bux, Sirajudin, Mauladad Khan, Maula Bux, and Gurmukh Singh.

† See index map at page 30 .

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTS. JUBBULPORE AND DAMOH.

No. 9 PARTY



Published under the direction of Lieut-Colonel H.H. Tweedie, R.E., Surveyor General of India.
Survey of India Office, Calcutta, October
1907

Photozincographed at the Survey of India Office, Calcutta.

traversing section of the Bilaspur Party, so that the entire Raipur Party may be transferred to the Nágpur and Wardha districts.*

JUBBULPORE AND DAMOH DISTRICTS, CENTRAL PROVINCES.

No. 9 Party.

237. This party, under Mr. G. H. Cooke, returned to Jubbulpore from recess quarters at Mussooree on 1st November, and immediately, on being subdivided into two sections, proceeded to resume traverse survey operations in Districts Jubbulpore and Damoh. The Jubbulpore section continued in the field until 1st May, and the Damoh section until 20th May, the recess station for both sections having in the meantime been changed to Jubbulpore.

Personnel.

Mr. G. H. Cooke, Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. J. Todd, Surveyor, 2nd grade.
„ H. Dowman, Surveyor, 3rd grade.
„ A. George, Assistant Surveyor, 2nd grade.
„ A. Ewing, ditto, do.
36 Sub-Surveyors and others.

238. The nature of the operations was the same as during the previous season, *viz.*, a system of skeleton traversing designed to form the basis of a field survey by the village *patwáris*, and consisting of traverse lines following closely the village boundaries, so as to admit of the actual boundaries being readily plotted by offsets, and in large villages, of additional traverse lines, at intervals of about 30 chains in cultivated lands, or separating the cultivation from the jungle in villages where the jungle was excessive.

239. Every survey station was marked by a roughly cut stone prism 2 feet long by 6 inches in thickness, many stones having to be embedded at dilapidated trijunction platforms as well as at the newly fixed stations. In all, 40,545 stones were embedded in both districts, furnishing an average of 16 marks per square mile, and being laid down at the average cost of R2-8 per square mile, the price of the stones being one rupee (per 16 stones) and one and a half rupee for carriage of the stones and for labour. The first class reserved forests were found to be demarcated by masonry pillars about 5 feet high and rounded at the top so that they could not be utilized as survey stations, and mark-stones had to be embedded at their bases. The second class forests are demarcated by cairns of stones only.

240. The out-turn of the season is shown in the following statement:—

Districts.	Number of Villages.	Number of Sub-Traverses.	Number of Traverse Stations including Trijunctions.	Square miles.
Jubbulpore	668	779	22,247	920
Damoh	909	1,228	24,671	1,670
Total	1,577	2,007	46,918	2,590

The traversing of the Damoh district has been completed. About 2,000 square miles remain to be traversed in Jubbulpore.

241. Observations for azimuth were taken at 263 traverse stations as checks on the angular work; and to test the chain measurements, connections were made on stations of the Great Trigonometrical Survey, which, with those connected last year, have enabled ten comparisons of rays to be made, with the result that the chaining has been found to have an average error of 3·64 feet per mile.

242. The intricate nature of many parts of the country operated in, more especially in the Jubbulpore district where much hilly and raviny ground was met with, added greatly to the labour of the traversing on account of the shorter lines and additional number of stations which had to be adopted. In office, the strain of dealing with the increased number of lines and angles has been chiefly

* Colonel Wilkins reports favourably of the following Surveyors and Assistant Surveyors, *viz.*, Messrs W. S. Buttress, A. Christie, C. Tapsell, and G. Vanderbeek. He also makes favourable mention of the following members of the native establishment, *viz.*, Bhagobutty Chunder Chuckrabutty, Kedar Nath, Mahomed Zakaria, Alladad Khan, Chaju Singh, Rameshardial, Hira Singh, and Dharaneedhar Mookerjee.

felt. Besides, there has been considerable difficulty in securing the mathematical proof of the village polygons in broken country, without many re-measurements of the lines. Thus it has not been possible to complete the whole of the office work by the end of the recess, and the return of completed work on 31st October showed that the skeleton plots of 331 villages in Jubbulpore and of 693 villages in Damoh had up to that date been furnished for the settlement survey. The office work connected with the remaining villages will be continued in camp during the field season without interfering with the new field work to be undertaken. Besides the skeleton plots, copies of the traverse data to enable these plots to be again projected if required, and statements of the areas of the polygons, are furnished to the Settlement authorities.

243. The total cost of the season's operations for twelve months ending 30th September has been R60,863 for the traversing and R6,475 for the station marks, giving the following rates, *viz.* :—

	Per square mile. R a. p.
For traversing	23 8 0
For stone-marks	2 8 0

The rate for traversing shows a reduction of R8 on the rate of the previous season.

244. The recess office of the party was inspected at Jubbulpore during September by the Deputy Surveyor General in charge of the Revenue Branch, who was satisfied that the character of the work which had been executed was good, and that, through the exertions of Mr. Cooke and all concerned, good progress had been made with the office computations, which on account of the intricate nature of the greater part of the country are exceptionally heavy.*

SEONI AND CHHINDWARA DISTRICTS, CENTRAL PROVINCES.

NO. II PARTY.

245. This party, which had been employed for thirteen seasons on topographical surveys in the Bombay Presidency, has been transferred, under instructions conveyed in Government of India, Revenue and Agricultural Department, letter No. 28—25-1, dated 11th January 1886, to the Central Provinces to undertake traverse surveys in aid of field surveys by village *patwáris* under the supervision of Settlement Officers. Districts Seoni and Chhindwara were assigned to the party, the operations in both districts being required to be undertaken simultaneously by separate sections.

Personnel.

Lieutenant-Colonel D. C. Andrew, S.C., Deputy Superintendent, 2nd grade, in charge.

Mr. W. A. Wilson, Surveyor, 2nd grade, from 6th November 1886.
Mr. J. Hickie, Assistant Surveyor, 1st grade.
„ P. White, Assistant Surveyor, 1st grade.
„ C. George, Assistant Surveyor, 2nd grade.
„ A. George, Assistant Surveyor, 2nd grade, up to 31st October 1886.

34 Sub-Surveyors and others.

246. A small detachment was sent from the recess quarters at Poona to Seoni in the beginning of October for the instruction of newly-entertained *employés* and for the collection of materials for permanent marks. The main body followed on the 1st November when the field establishments were fully entertained and field work was commenced. Field operations were continued by the Seoni section up to the end of June and by the Chhindwára section up to the end of July, the office establishments being withdrawn about these dates to Poona, which had been retained as the recess station of the party.

247. The operations were of the same character as those which had been undertaken for the same purpose during the previous seasons in other districts of the Central Provinces, in accordance with the specification of the Chief Commissioner. Boundary traverse lines were placed so that the offseting

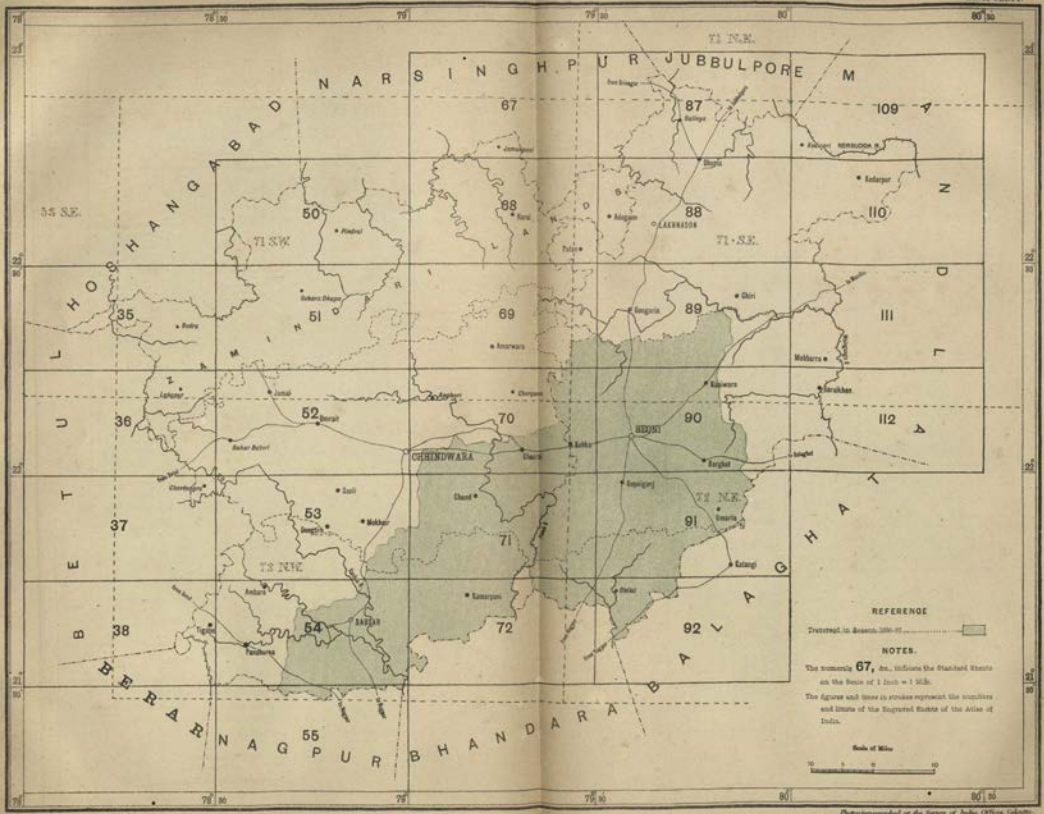
* Mr. Cooke makes special mention of Mr. H. Dowman for accurate and extensive work in connection with the Damoh section which he supervised. The Jubbulpore section was supervised by Mr. J. Todd satisfactorily. Messrs. A. George and A. Ewing are favourably mentioned.

The following members of the native establishment are commended, *viz.*:—Taraprosono Roy, Lal Mohun Gungopadhya, Monohar Daji, Upendra Nath Mokerjee, Kesho Baijnath, Gopal Setaram, Purna Chunder Dass, Behari Lall, Mahmud Bux, Irfan Ali, Rur Singh, Murli Monohar, Piari Lall, Ganpat Rai, Moorad Ali, Prag Singh and Suchait Singh.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICTS SEONI & CHHINDWARA.

No. 11 PARTY.



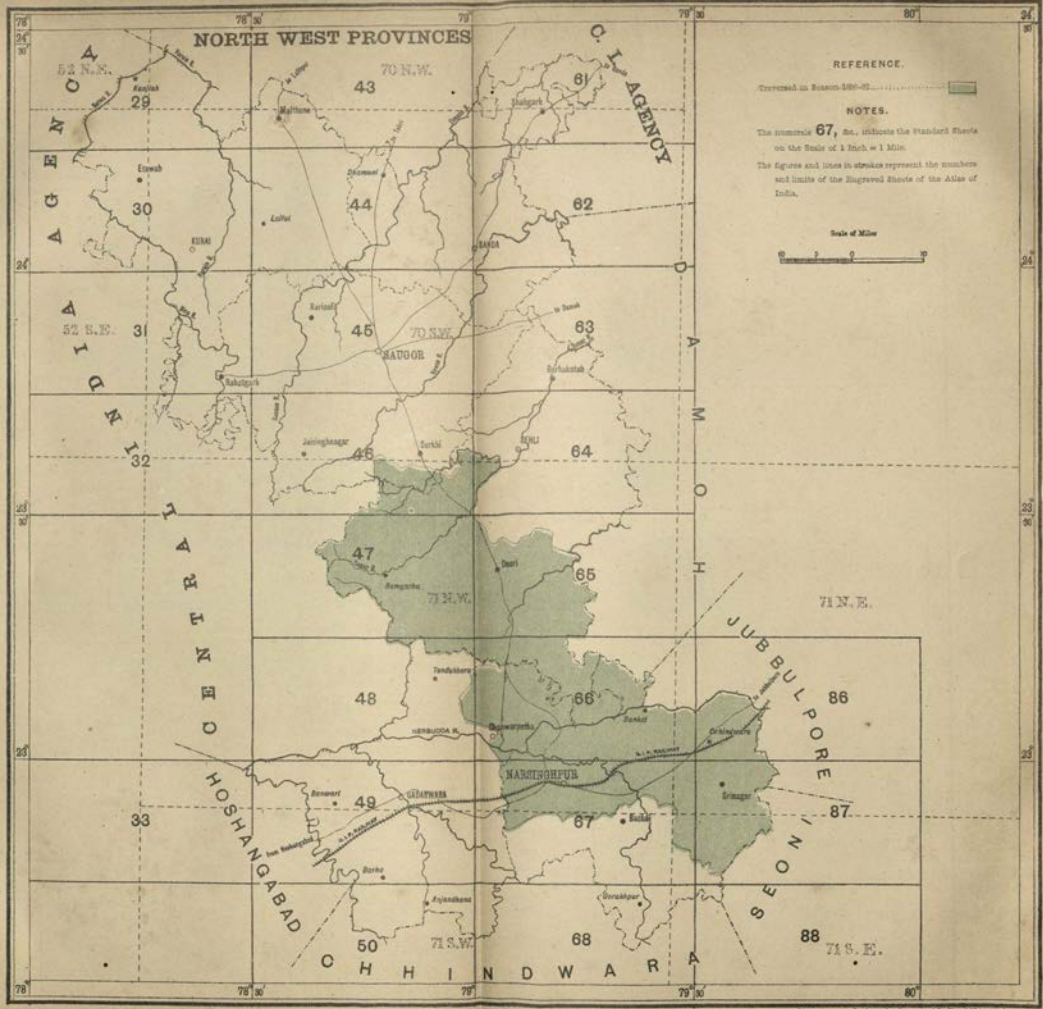
Published under the direction of Lieut.-Colonel H. H. Thuillier, R.E., Surveyor General of India.

Survey of India Office, Calcutta, August 1897.

Photozincographed at the Survey of India Office, Calcutta.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICTS SAUGOR & NARSINGHPUR. No. 12 PARTY.



Published under the direction of Lieut. Colonel H. H. Thuillier, R. E., Surveyor General of India.
Survey of India Office, Calcutta, August 1867.

Photozincographed at the Survey of India Office, Calcutta.

distances did not exceed 2 chains; sub-traverses to subdivide large villages were laid out at intervals of about 30 chains; chain lines were kept under 30 chains in length (the average length of the lines being only 14·3 chains); and every traverse station was permanently marked with a stone at least 2½ feet in length. Also, skeleton plots of the traverses on the 16-inch scale, with statements of the areas of the polygons, were begun to be furnished during the recess to the Settlement authorities; and copies of the traverse data, to enable the skeleton maps to be replotted if necessary, were likewise prepared.

248. The areas, of which the field work has been completed in each of the districts, are shown separately in the following statement:—

Districts.	Number of villages.	Number of sub-traverses.	Number of Theodolite stations.	Area in square miles.	Remarks.
Seoni . . .	537	732	16,275	1269·5	Besides the villages herein returned, there are 79 forest blocks.
Chhindwára . .	512	650	16,157	1042·5	
Total .	1,049	1,382	32,432	2312.0	

249. Observations for azimuth have been made at 175 traverse stations, and connections have been effected on 4 stations of the Great Trigonometrical Survey. Although the field work of the area stated above has been completed, the office work has only been entirely finished for the Seoni area, of which the skeleton plots on the 16-inch scale have all been supplied to the Settlement authorities, while of the Chhindwára area the plots of about one-third only had been sent on 30th September, the main cause of the delay being the inexperience of the establishments transferred from topographical work or newly entertained, whose work has required considerable revision. It is expected that the Chhindwára work will be fully rendered during January.

250. The recess office of the party was inspected at Poona during September by the Deputy Surveyor General in charge of the Revenue Branch, who found the standard of work executed by the party to be good, and that everything possible under the circumstances was being done to bring up the arrears of the Chhindwára work.*

SAUGOR AND NARSINGHPUR DISTRICTS, CENTRAL PROVINCES.

No. 12 Party.

251. This party, formerly the Cutch Topographical Party, has been brought up to the Central Provinces and re-organized for traverse surveying in accordance with the instructions conveyed in the Government of India, Revenue and Agricultural Department, letter No. $\frac{326}{36-10}$, dated 2nd September 1885.

Personnel.

Colonel A. Pullan, Deputy Superintendent, 2nd grade, in charge up to 28th October 1886.
Mr. E. J. Jackson, Deputy Superintendent, 4th grade, in charge from 29th October 1886.
Mr. A. J. Gibson, Surveyor, 2nd grade, from 1st November 1886.
Mr. W. R. Vyall, Surveyor, 3rd grade.
„ J. T. U. Coxen, Surveyor, 4th grade (was on medical leave from 10th November 1886 to 9th May 1887).
Mr. C. Tapsell, Surveyor, 4th grade, up to 31st October 1886.
Mr. G. T. Hall, Assistant Surveyor, 1st grade.
„ H. A. Charrier, Assistant Surveyor, 3rd grade.
40 Sub-Surveyors and others.

252. Mr. E. J. Jackson, on return from furlough, was appointed to the charge of the party, *vice* Colonel A. Pullan, transferred to No. 17 Party (Gujarát), and having relieved Colonel Pullan at Poona on the 28th October he immediately proceeded to Narsinghpur, which he reached on 31st October. The establishment had then all assembled and field operations were at once commenced. The party remained in the field, notwithstanding the intense heat experienced after 15th April, until 27th May, when it moved into recess-quarters at Saugor.

* Colonel Andrew reports favourably of Mr. W. A. Wilson, who was in charge of the Seoni section, and mentions Mr. C. George as an energetic and willing assistant. The following members of the native establishment are also commended, *viz.*, Chandoo Meean, Krishnaji Mahadeo, Shadi Lall, Rambharoselall, Ram Richa, Ram Jas, Sitaram and Bhagwan Deen Tribedi.

253. Owing to the establishment consisting mainly of apprentice surveyors who had been newly entertained so as to raise the topographical survey nucleus to the requisite strength, the out-turn of the party has not been equal to that of the other parties which have had for longer a special organization for traverse surveying; and besides the deficiency of experienced surveyors, the new party has also felt the want of a full complement of trained menials on whose expertness the rapidity and accuracy of the chain measurements chiefly depends. Mr. Jackson has energetically encountered these difficulties, and though he has not been able to obtain credit for a very large out-turn, he has carefully guarded against inferior work by insisting on re-measurements wherever the apprentices' work did not come up to the usual standard. There were also disappointments through apprentices failing to qualify who had to be discharged after time and labour had been lost in their instruction. It should likewise be mentioned that many parts of the country were very rocky and covered with jungle which greatly hindered the work of the traversers.

254. As the operations were required to be carried on simultaneously in two districts, the separate localities for beginning work were selected as near to each other as possible for convenience of supervision, and the extreme southern part of the Saugor district, though presenting many difficulties to a new establishment from its rugged character, was first entered upon. In Narsinghpur, the operations were begun from the east on the Jubbulpore boundary. The nature of the work has been the same as was carried on during the previous season by other traverse survey parties in the Central Provinces according to the specification of the Chief Commissioner, the work being specially designed to form the basis of a survey of fields by village *patwáris*, and consisting of traverses following closely the lines of the village boundaries with additional sub-traverses in large villages. As required by the same specification, the theodolite traverse stations have all been marked with stones either specially quarried and transported for the purpose or such as were already found standing as village boundary-marks. Most of the tri-junction points were found to be already marked with masonry platforms, but for many, temporary materials only had been used, and at these points stones were embedded. In all, 26,071 stones were put down, *viz.*, 12,518 in Saugor and 13,453 in Narsinghpur.

255. The areas that have been accomplished in both the districts are shown in the following statement:—

Districts.	Number of villages.	Number of sub-traverses.	Number of stations.	Area in square miles.
Saugor	427	570	14,266	771
Narsinghpur	539	767	15,790	784
TOTAL	966	1,337	30,056	1,555

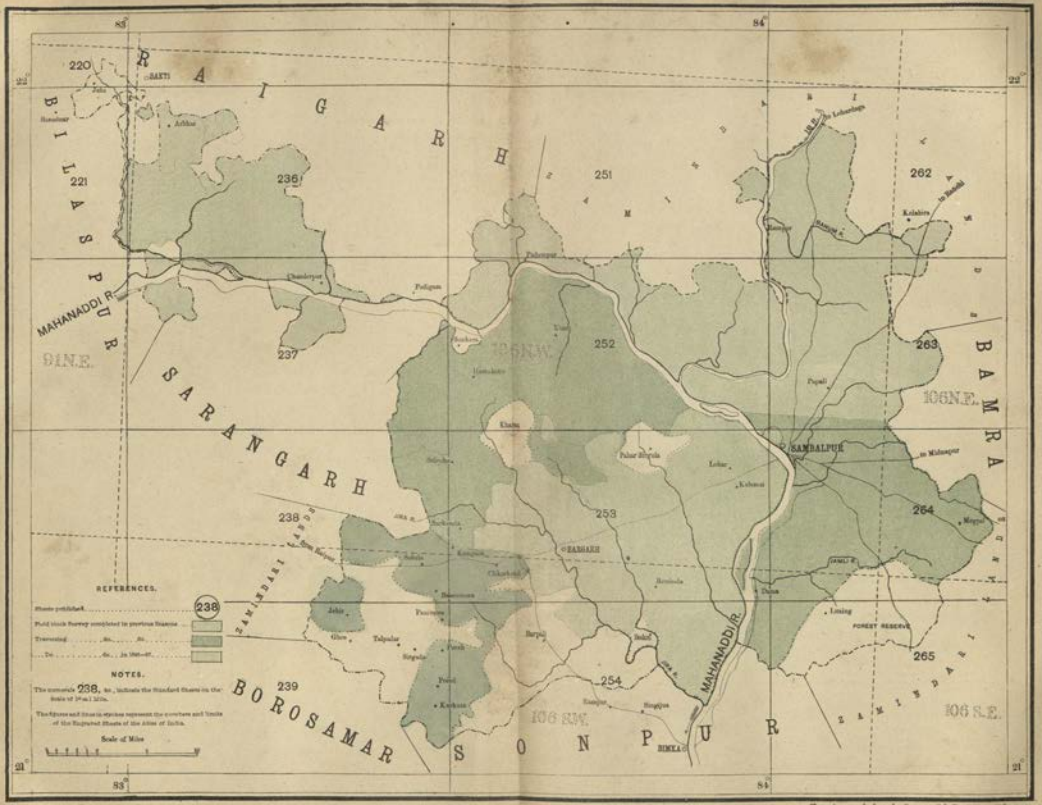
The aggregate length of the traverse lines is 5,100 linear miles. During the operations, 88 new sets of observations for azimuth were taken, and 24 sets of observations taken during the Jubbulpore and Damoh survey on the common boundary were utilized. Connections were made with 6 stations of the Great Trigonometrical Survey, furnishing the means of comparing the direct distances of 8 rays with the measured distances of the same and showing that the latter have an average error of 5·9 feet per mile.

256. Owing mainly to the want of experience of a large number of the members of the new establishment, the work of many having to be revised, the computations of all the villages that have been surveyed have not been completed during the recess, and at the end of the season 92 villages in Saugor and

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT SAMBALPUR.

No. 13 PARTT.



Published under the direction of Lieut.-Colonel H.H.Tremlett, R.E. Surveyor General of India.
Survey of India Office, Calcutta, September.
1897

Photozincographed at the Survey of India Office, Calcutta.

241 in Narsinghpur remained unfinished. In Saugor, 335 villages had been completed and 481 plots furnished; in Narsinghpur, 298 villages and 491 plots. The incomplete records will be proceeded with during the field season, as soon as re-measurements can be made.

257. The areas remaining for survey are 3,242 square miles in Saugor and 1,140 square miles in Narsinghpur. The traversing of the latter district will be finished during season 1887-88, but about 1,780 square miles of Saugor will be left over for the following season.*

SAMBALPUR DISTRICT, CENTRAL PROVINCES.

No. 13 PARTY.

258. This party under Mr. D'Souza resumed traverse operations in the Sambalpur district on 23rd November 1886, and continued to work up to 20th April 1887, when, on completing the tracts for which traversing was required in Sambalpur, it returned to recess-quarters in Nagpur.

Personnel.

Mr. A. D'Souza, Assistant Superintendent, 1st grade, in charge.
Mr. P. A. G. Cowley, Surveyor, 1st grade, on medical leave.
Mr. C. W. F. Seyers, Assistant Surveyor, 1st grade.
Mr. C. S. Kraal, Assistant Surveyor, 1st grade, up to 30th April 1887.
Mr. T. W. Babonau, Assistant Surveyor, 2nd grade, from 1st May 1887.
22 Sub-Surveyors and others.
18 Temporary ditto.

259. The traverse work has been of the same character as during the previous season, having for its object the preparation of skeleton maps of villages on which the field details would be plotted by the village *patwáris* working under the Settlement Officer. Besides the traverse stations established on the village boundaries, other stations were also established by means of sub-traverses within the large villages, and all the stations were secured with permanent marks.

260. The out-turn is as follows:—

Number of villages	469
Number of sub-traverses	660
Number of stations	10,404
Linear miles of traversing	2,808
Area in square miles	969

Observations for azimuth were taken at 75 traverse stations, and connections were made on 5 stations of the Great Trigonometrical Survey, which furnished tests showing that the traverse measurements have an average error of 2·65 feet per mile.

261. In order to meet the requirements of the programme of the Settlement Officer, special arrangements were made to push on the office computations during the field season, and 746 plots were furnished for the use of the village *patwáris* before the party left the field. The remainder of the plots, 366 in number, and area statements for the entire tract, were all supplied at the end of the recess season.

262. This party which has hitherto been only of half strength has been raised to full strength from 1st October 1887, in order that it may be employed in two sections on the traverse surveys of the Hoshangabad and Betúl districts required to be carried on simultaneously.

263. The recess office of the party was inspected at Nagpur during September by the Deputy Surveyor General in charge of the Revenue Branch, who expresses himself as having been well satisfied with the character of the records that had been prepared as well as with the manner in which Mr. D'Souza had carried out all duties connected with the superintendence of the party.†

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* Mr. Jackson reports very favourably of Mr. G. T. Hall, also of the undermentioned members of the native establishment, *viz.*, Rhidoy Chunder Dass, Jogendra Nath, Govindro Swamy, Abdul Guni, Narsoo Dinkur and Balkishen.

† Mr. D'Souza reports that Messrs. Seyers and Kraal have both done excellent work.
Of the native establishment, Boith Ram, Rajdhari Lall, Abdul Khalik, Ram Dass, Dahini Khan, and Narain Pershad are specially commended.

GEODETIC.

NOS. 22 AND 23 PARTIES (ASTRONOMICAL).

LATITUDE OPERATIONS.

264. Owing to there being but one officer available for astronomical work, as was stated in paragraph 282, page 58 of last year's Report, the Telegraphic Longitude operations were suspended and Latitude operations resumed during the year under report. In 1884-85 Lieutenant-Colonel Heaviside had carried these operations from north to south over the Amúa Meridional Series, his last station being Potenda in latitude 24°37′, and Lieutenant Burrard has continued the operations as far south as Rájuli, a station of the Jubbulpore Meridional Series in latitude 20°13′, in pursuance of the design to have a series of latitude stations, about half a degree apart as near as may be to meridian 80°, from the Himalayas to Madras. Lieutenant Burrard's work consists of observations at five stations, a very creditable number, considering that his working season was curtailed at both ends. Having had no experience with a zenith sector, he remained nearly a month at Dehra Dún at the beginning of the season for preliminary practice; he was further detained for ten days at Nágpur on account of the very unhealthy state of the country where his operations were to commence (as reported by the Civil Surgeon), but he improved this occasion by establishing a latitude station at Nágpur at which he took complete observations. He had to close field operations early, that is to say, on 1st March, in order to undertake a series of experiments at Dehra Dún with the longitude transit instruments. His work, as judged by the accordance of his zenith distance measures, compares well with the best work of his predecessors.

Personnel.

Lieutenant S. G. Burrard, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Babu Harsahai, Recorder.
Babu Dhondu Balwant Joshi, Computer.
Babu Mangat Rai, Writer.

ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

265. Though there is nothing to report in the way of direct progress in these operations, mention has now to be made of the various experimental observations that have been undertaken for the testing of the telescopes employed thereon, concluding with the exhaustive series of experiments projected in accordance with the intimation in paragraph 285, page 59, of last year's Report, and carried out in March and April last. These instruments were made by Messrs. Cooke and Sons in 1870 and 1871, and despatched to India early in 1872. They are, it is believed, the largest of the kind ever made as *portable* transit instruments, and the experience gained from their performances from the first to the present time leads to the suspicion that they are too large and ponderous to stand the vicissitudes of transport to which they are of necessity exposed. During their first season's work in 1872-73, one of them (called No. 2) was found to be so capricious in its performance that the two arcs then measured had both to be rejected. The cause of this failure was easily detected and was remedied, and throughout three subsequent field seasons the instruments worked satisfactorily, but the results of the fourth season's (1881-82) work indicated that unsteadiness was creeping in again in one or other of the instruments. This time, however, the *locale* of the cause of error was by no means easy to discover, for the existence of error was only shown when the observations were reduced and the errors of circuits* of three arcs taken out, no signs of instrumental unsteadiness having presented themselves while measuring the individual arcs. There were three such circuits, the first two of which showed errors much larger than had occurred before, while the third, formed by the three arcs last measured in the season, had but a normal error which was probably due to fortuitous cancelment of large arc errors and which ministered the unpleasant *caveat*, that while a large circuit error proves the *presence* of large arc errors, a small circuit error by no means proves the *absence* of large arc errors. Instrumental weakness was

* For an explanation of this term see note † at foot of page 59 of last year's Report.

accepted as a fact though its *locale* was not actually discovered; the instruments were sent into the Mathematical Instrument Office, Calcutta, and the parts where weakness had before been detected were further fortified. After this, work was resumed and carried on during two field seasons with fairly good results, but indicating nevertheless the presence of a capricious source of error which could not fail to cause continued anxiety to the observers and general distrust in the degree of accuracy exhibited by even small circuit errors which might possibly conceal large arc errors. The instruments were therefore sent back to England in 1884, to be carefully overhauled by the makers and to have every possible seat of weakness or instability strengthened or renovated. The makers carried out these instructions, and on account of suspicion attaching to the bearings in which the axial pivots revolved and which were of a very beautiful but novel design* they supplied new Ys of the old established pattern. Lieutenant-Colonel G. Strahan, R.E., then on furlough in England, was deputed to examine the instruments on the makers reporting the execution of their orders. As stated in paragraph 284, page 58, of last year's Report, Colonel Strahan carried out his examination in the enclosure of the Greenwich Observatory. One oversight of the makers in wiring the micrometer diaphragms necessitated the return of the instruments from Greenwich to York for correction. This done, they were sent back to Greenwich, and Colonel Strahan examined them to see that they were in good working order. After satisfying himself that the line of collimation in each instrument was practically permanent as regards freedom from *lateral* displacement, by revolving the instrument through various arcs and pointing it after each arc motion on the cross of a collimator, bringing it to the cross alternately from above and below, he then with each instrument took a series of star transits, having selected 24 stars, of which half transited north and half south of the zenith, devoting three nights to instrument No. 1 and four nights to No. 2, changing the position of the pivots† in the middle of each night's observations. Colonel Strahan's observations as far as they go are complete, and his report full and precise. The object of the observations was to see that the makers' orders had been thoroughly executed; and having satisfied himself that such was the case, Colonel Strahan "passed" the instruments, and they were sent back to India in time for resumption of the longitude operations in the field season of 1885-86. Colonel Haig, the Deputy Surveyor General in charge of the Trigonometrical Branch, however, having carefully analyzed Colonel Strahan's report, noticed that the observations, if treated similarly to those of 1883-84, of which the results are given in Table III, page lxxv, of the Report for that year, indicated the presence of residual errors in the two instruments respectively of $-\cdot065$ and $-\cdot068$ of a second in place of $-^{s}\cdot011$ and $+^{s}\cdot140$ as there exhibited, and, moreover, that there were indications of some accidental error on one night at Greenwich, which, if corrected as appearances seemed to justify, gave a set of very uniform results, but increased the residual of No. 2 from $-^{s}\cdot068$ to $-^{s}\cdot128$. Now if these residuals were invariably found to exist and to maintain a constant or fairly constant value, it would virtually solve the mystery that has been causing the trouble and discussion of the past few years, for they represent the respective correction peculiar to each instrument necessary to be applied to the means of two sets of observations—one taken with I. P. E. and the other with I. P. W. It was, therefore, thought advisable before regular operations were resumed, to take the further series of experiments at Agra mentioned in paragraph 284, page 59, of last year's Report. These observations occupied twelve nights—six to each instrument—24 stars, 12 north and 12 south of zenith, being observed every night with a change of pivot position in the middle; and the evidence of the results was much more favourable than that of Colonel Strahan's observations, and went towards largely reducing the residuals of both instruments—the five values of that of No. 1 ranging from $-^{s}\cdot005$ to $+^{s}\cdot035$ with a mean of $+^{s}\cdot017$, while the five values of that of No. 2 had the still smaller range from $-^{s}\cdot025$ to $-^{s}\cdot040$ with a mean of $-^{s}\cdot033$. These results, while failing to establish the constancy of the residuals determined by Colonel Strahan's lesser series of observations, confirmed his testimony to the proper fulfilment of

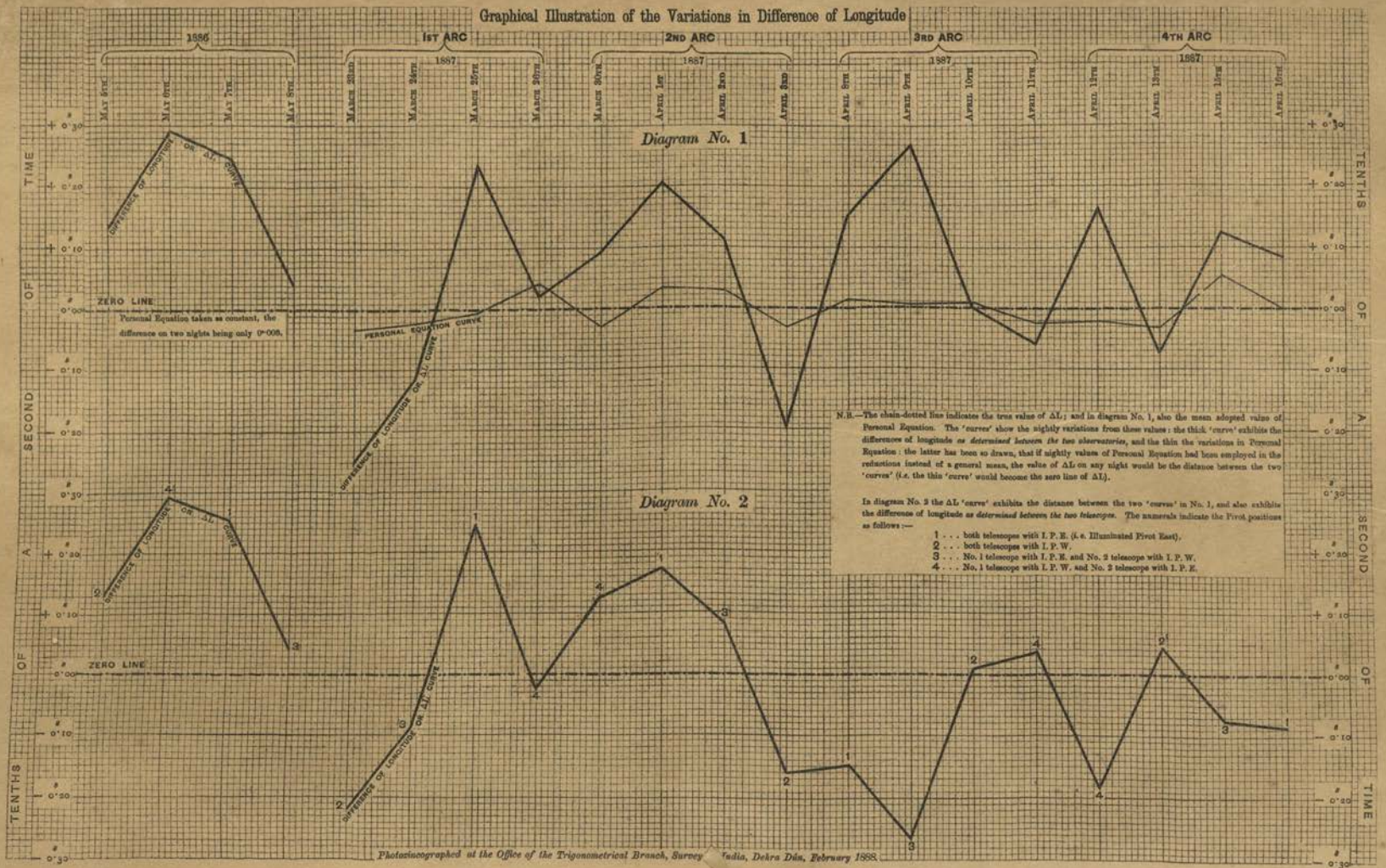
* This is fully described in Professional Volume IX, page 3.

† In each instrument one of the pivots is perforated for the purpose of illuminating the wires and is called the "illuminated pivot": the term always used to denote the position of the instrument when that pivot is to the east is defined as I. P. E., and when west, I. P. W.

their engagement by the makers, and regular operations were at once resumed. During the field season nothing occurred to shake the confidence of the observers in the perfection of the instruments. Nine arcs were measured, and in order to test the accuracy of the observations for personal equation, there was an interchange of observers on one of the arcs in the middle of the observations, four nights being given to each disposition, the respective telescopes and equipment remaining fixed. The result showed a difference between the two observers, Colonels Strahan and Heaviside, of ·082 of a second, while two sets of observations taken by them in the ordinary way gave one a difference of but ·003 and the other of ·068 of a second. At the end of the season an experimental arc was measured, the two instruments being placed on the same meridian 51½ feet apart, in order to see what error would occur in the measurement of an arc the exact magnitude of which was known (*viz.*, $\Delta L = 0^s{\cdot}000$). When the season's observations came to be reduced, the results were most disappointing, three out of five circuit errors being abnormally large, *viz.*, $-^s{\cdot}325$, $-^s{\cdot}257$, and $+ ^s{\cdot}251$, and the single experimental arc having an error of $0^s{\cdot}180$. These results occurring in the face of abundant testimony to the excellence of the instruments, Colonel Haig determined to have a further and exhaustive series of observations taken on the experimental arc at Dehra Dún, in the course of which there should be every possible interchange of observers, telescopes, electrical apparatus and stations, so as to localize the source or sources of error if it should still be impossible to determine the precise causes. This series of observations was undertaken by Lieutenant Burrard, assisted by Mr. Eccles, in March and April last, and a detailed report thereon drawn up by Lieutenant Burrard will be found at page xxiv of the appendix. These experiments go to show that the Longitude operations have been harassed by three sources of error, *viz.*, (1) electrical, (2) local, and (3) instrumental. The discovery of the *electrical* cause of error is valuable. It was always supposed that the "retardation" in transmitting a signal depended on the length of the line of wire between the two stations, and it was the custom to divide the retardation equally over the two passages from east station to west, and from west station to east; whereas it has been established that the retardation on the line wire is practically *nil* and that the whole amount may be caused by the chronograph at one station. This being discovered, the retardation caused by each chronograph will, in future, be independently measured each night by a simple process, and the difference between the retardations at the two stations on any night will afford a correction to all the measures of the arc of longitude taken that night. The error caused by neglecting that correction is variable; sometimes during the experiments it was observed to amount to ·05 of a second, but on examining the records of the observations of the Agra-Mooltan arc, the retardation was found to be ·4 of a second on one night, and if this was entirely due to one chronograph, the error in the mean of that night's observations due to dividing it equally between the two would be ·2 of a second, and this would affect the general mean of the six nights by ·033 of a second.

266. The presence of a *local* disturbing force seems to be pretty clearly established. Since the two instruments were within a few yards of each other, the effect of "local attraction" causing deflection of the plumb-line would of course affect both instruments alike; but it appears that there was a local disturbing force causing stars to transit earlier in one observatory than in the other, irrespective of the instruments with which they were observed. The mean value of the effect of this force was ·052 of a second. The only apparent difference in the environments was, that while one instrument was surrounded by a tent the other was in a built observatory and rather close to the large photo-heliographic observatory, and if this difference produced such an effect, it is not unlikely that other local accidents have affected the measurement of many arcs to a similar extent. If, however, the disturbing force be constant, it would not affect the closing of the circuits, as it would operate equally on all arcs meeting at a station, unless those arcs were not all measured during the same season and the local conditions were altered in the *interim*; but supposing it were due to lateral refraction from want of homogeneity of atmosphere caused by currents of air circulating round an adjacent building, it would be liable to some fluctuation varying both with the season of the year and the night, and this would affect circuit error. It is noticeable that the error ascribed to this disturbance has the same sign as the error in the measurement of the experimental arc in May 1886,

Graphical Illustration of the Variations in Difference of Longitude



N.B.—The chain-dotted line indicates the true value of ΔL; and in diagram No. 1, also the mean adopted value of Personal Equation. The 'curves' show the nightly variations from these values: the thick 'curve' exhibits the differences of longitude *as determined between the two observatories*, and the thin the variations in Personal Equation: the latter has been so drawn, that if nightly values of Personal Equation had been employed in the reductions instead of a general mean, the value of ΔL on any night would be the distance between the two 'curves' (i.e. the thin 'curve' would become the zero line of ΔL).

In diagram No. 2 the ΔL 'curve' exhibits the distance between the two 'curves' in No. 1, and also exhibits the difference of longitude *as determined between the two telescopes*. The numerals indicate the Pivot positions as follows:—

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, February 1888.

and that its mean as determined by Lieutenant Burrard measures more than a quarter of the amount of the latter error.

267. In the investigation of the sources of error, Lieutenant Burrard has assumed that the local disturbing force is constant. It is probably not really so, but its variation is likely to be small in comparison with the fluctuations in the nightly mean measures of difference of longitude, otherwise it would have led to detection before both here and in other parts of the world. It is, therefore, convenient to suppose it constant for the facile exhibition of the inconstancy of the nightly means under one source, and to the *instrumental* cause of error has been ascribed the whole of the caprice in those means. The caprice has this strange peculiarity, that while it is capable of producing a difference ranging from +·175 to − ·175 of a second between the times of meridional passage of a zenith star, as observed by the two telescopes, the amount of that difference remains constant through any one night's observations, though probably the constant would change were change made in the disposition of the observers, telescopes, or pivots, in the course of a night's work, which was, however, not done, and is not now usually done in the ordinary routine work. The only way to deal with this enemy is to distribute the observations over a sufficient number of nights, that the error varying in its caprice from night to night in quantity and sign may nullify itself to a great extent when striking the general mean of all the nights. If the "probable error" on any night from this mysterious cause be ± ·088 of a second; and six nights (the usual number) be given to the measurement of each arc, the mean of the six nights would have a reduced "probable error" of ± ·036 of a second; but beyond six nights it would not be expedient to extend the observations, for the reduction in the "probable error" would not be an adequate compensation for the cost, *e.g.*, nine nights would only reduce the "probable error" to ·030.

268. Besides the three principal causes of error, Lieutenant Burrard has deduced two minor causes, and he regards them as constant; one an inherent difference between the two telescopes equal to ·017, and the other an inequality of resistance offered to electric currents by the two chronographs equal to ·015, which can be made to cancel each other by always using the quick chronograph with the slow telescope.

269. The results of each night's observations and their fluctuation, of which it has been sought to discover a law instead of ascribing them to caprice or accident, are now graphically exhibited in the accompanying diagrams which include the experimental arc measurements of 1886, as well as those of 1887. It will be observed that there are exhibited in all twenty nights' work divided into arcs of four nights each. On each arc a night was given to each of the four pivot positions, *i.e.*, (1) both instruments with I. P. E., (2) both with I. P. W., (3) No. 1 with I. P. E., and No. 2 with I. P. W., and (4) No. 1 with I. P. W., and No. 2 with I. P. E. The arc of 1886 was measured as in the ordinary way without any interchange of telescopes between the observers or observatories. Each arc of 1887 was marked by a change. Between the first and second arcs there was an interchange of observers only: between the second and third there was an interchange of both telescopes and observers; and between the third and fourth there was another interchange of observers only. In the regular operations it is usual to take advantage of occasions as they may occur when the two observers are together to take observations for relative personal equation, and as the variation between the personal equations determined on such occasions is supposed to be generated gradually, a graduated correction for it is applied to the arcs; proportionate to the intervals between their measurement and the personal equation determinations. At Dehra Dún during the 1887 experiments, observations for personal equation were taken every night. During the 1886 experiments, such observations were taken on two nights only, and with results so very accordant that the difference between applying the actual correction on those nights of determination and applying a mean or proportionate correction is practically *nil;* but in the 1887 experiments, the differences from the mean are sufficiently appreciable to exhibit on the diagrams. Across the centre of the diagrams will be seen a chain-dotted zero line. In the upper diagram, on the vertical line accorded to each date, two points are plotted: these points indicate by their distance from the zero line, the respective values of (1) the observed difference of longitude (the true difference being 0·000), and (2) the deviation of that night's personal equation from the mean of all the nights; and,

therefore, two series of points are formed, and these are exhibited by the thick and thin continuous but crooked lines, called respectively "difference of longitude or ΔL curve" and "personal equation curve." The actually observed difference of longitude on each night is represented by the distance between these two "curves." On the first glance at this diagram it will be noticed that the ΔL (difference of longitude) "curve" is violently erratic, while the P. E. (personal equation) is very moderately so; only in one instance, *viz.*, between the last two nights, is the fluctuation in the former less than that in the latter. Now each of the points furnishing the ΔL "curve" is, as a rule, the mean of 32 observations to as many stars, and each of the points furnishing the P. E. "curve" is the mean of eight observations to as many stars. Supposing all the individual measures from which each mean in both curves is derived were plotted on the diagram, there would be instead of the single point marked by the "curve," a row of 32 points at each angle of the ΔL "curve" and one of eight points at each angle of the P. E. "curve," the great majority of points in the ΔL row would lie within two-twentieths of an inch on either side of the curve with an occasional larger digression, and the largest digression of all would be seven-twentieths. [*N.B.*—The paper is divided into halves and twentieths of an inch, a half-inch representing one-tenth of a second of time.] A similar description would almost exactly suit the P. E. rows of points. The lower diagram is but a modification of the upper: in it the distances of the ΔL "curve" from the zero line are equal to the distances between the two "curves" in the upper, and for the last two arcs those distances have been plotted on the opposite side of the zero line, so that while the upper diagram exhibits the ΔL observed between the two observatories, the lower exhibits the ΔL observed between the two telescopes, and this is convenient for exhibiting the positions of the pivots on each night. The four positions have been enumerated above, and they are indicated by the numerals 1, 2, 3, 4 on the lower diagram. The perplexity involving the problem which it has been attempted to solve, may be estimated by the erratic character of the ΔL "curve" in the face of comparative consistency between the measures from which each point in the curve is derived. It is evident from inspection of the ΔL "curve" that the vagaries are such that even sixteen or twenty nights are insufficient for the deduction of very precise conclusions, though they are sufficient to indicate the sources from which the variations proceed; and in future operations all precautions will be taken so as to preclude errors which cannot be called accidental, and to make those which can be so called, neutralize each other as much as possible. Further detective measures have also been devised and will be adopted, so that, while the regular operations progress, all possible light may be thrown on the nightly caprice of the mysterious disturbing force. After all, it should be remembered that the variations that are brought so prominently to view in the diagrams are in reality of very small magnitude, and that by no other means could difference of longitude be measured with any approach to the accuracy attained in these Telegraphic Longitude operations.*

TIDAL AND LEVELLING OPERATIONS.

NO. 25 PARTY.

270. The direction of these operations was under Major J. Hill, R.E., throughout the year. Major Baird, on his return from officiating as Master of the Calcutta Mint, rejoined the party and assisted in the preparation of the Tide Tables for 1888 until his transfer to the head-quarters offices at Calcutta.

Personnel.

Major J. Hill, R.E., Offg. Deputy Superintendent, 2nd grade, in charge.
" A. W. Baird, R.E., F.R.S., Deputy Superintendent, 3rd grade, attached to party from 8th January to 25th May 1887.
Mr. G. Belcham, Surveyor, 3rd grade.
" E. J. Connor, " 4th " "
" H. Corkery, B.A., LL.B., Assistant Surveyor, 1st grade.
Sub-Surveyors Narsing Das and Dhondu Venayek and 16 recorders and computers.

* Lieutenant Burrard reports very favourably on his Observatory Recorder, Babu Har Sahai.

TIDAL OPERATIONS.

271. The recording of the tidal curves by means of self-registering tide gauges, their reduction and the publication of predicted heights have been continued as usual during the past year, during which tidal observations were carried on at 17 stations, namely:—*Aden*, *Kurrachee*, Bhávnagar, *Bombay*, Mormugáo (Goa), Cochin, Colombo, Galle, Negapatam, *Madras*, Cocanada, *Kidderpore*, Chittagong, Akyab, Elephant Point, *Rangoon* and *Port Blair*. The ten tidal stations the names of which are not italicised, are minor stations at which as a rule only five years' registrations are required, after the completion of which period the instruments are removed and set up elsewhere. The seven names which are italicised are those of permanent stations where tidal observations should be continued until the work at all the minor stations is completed.

272. Since the date of the last Annual Report, work has ceased at two tidal stations. On the 9th October 1886, the Amherst observatory was closed and the instruments sent to Akyab: and on the night of the 29th September 1886, the tidal observatory at Dublat, near the mouth of the Hooghly, was swept away with all its contents by a heavy wind and sea, and none of the instruments or records could be recovered. Fortunately the clerk was absent, and the accident was unattended with loss of life. Dublat used to be regarded as a permanent tidal station, and five years' registrations had been completed at the observatory about five months before its destruction; but the station is now classed as a completed minor one, and it is unlikely that the observatory will be re-established. As it is desirable, however, to have one permanent tidal station on the Hooghly, Kidderpore now occupies that position.

273. One new tidal observatory has been established during the year under report: this is at the minor tidal station of Akyab, and its registrations commenced on the 9th May 1887. Particulars regarding its erection will be found in the appendix.

274. It will be seen from the foregoing, combined with the particulars given in the last Annual Report, that since the resumption of systematic tidal operations in 1877, observations have been taken at 26 tidal observatories, of which 9 have been closed on the completion of their registrations and 17 are now in operation.

275. When an observatory is closed, it is desirable to set up in its place a graduated staff the zero of which should correspond with the datum to which the heights at the station in the Tide Tables are referred, so as to obtain actual values to compare with the predictions. This has been done at Moulmein, and arrangements have been made for setting up another at Amherst. As opportunity offers, similar staves will be introduced at all the tidal stations where observations have been completed.

276. The places which appear most suitable for selection as future minor tidal stations are Tuticorin, Mergui, Singapore, Fao telegraph station at the mouth of the Bussora river in the Persian Gulf, and a site in the Gulf of Siam in about the latitude of Mergui to be, if possible, connected with Mergui by spirit-levelling. Another proposed site for a tidal station is Diamond Island at the mouth of the Bassein river, mentioned in the last Annual Report; but recently received information appears to show that the difficulty of communicating with it during the rainy season would probably neutralize its advantages, and it seems doubtful now whether a tidal observatory can advantageously be established there. It has accordingly been decided to establish Tuticorin and Mergui as tidal stations before taking any steps towards setting up a tidal observatory at Diamond Island.

277. All the observatories with the exception of Aden have been inspected either by the officer in charge of the party or by one of his assistants.

The usual account of the working of each observatory will be found in the appendix. On the whole the registrations have been very satisfactory; failures have been few and for the most part unimportant; the observatory clerks know their duties and perform them punctually, and the officers who superintend the registrations of the several tidal stations spare no pains, as a rule, to ensure good results.

278. The reductions of the observations have been carried on steadily during the year. The observations for one year at 12 ports and for two years at 3 ports

have been reduced, equivalent to the reduction of the observations at 18 ports. The tabulated values of the tidal constants and the discussion of the results will be found in detail in the appendix.

279. In addition to the current calculations the usual work in connection with the yearly issue of the Tide Tables for 1888 has been satisfactorily accomplished. These tables will contain the predictions of the heights and times of high and low water for 27 ports, being four more than in the volume for 1887.

280. The results of the predictions for 1886 may be summarised as follows:—

Percentage of predictions within 15 minutes of actuals.

	High water per cent.	Low water per cent.
Open coast stations	67	66
Riverain	68	66

Percentage of predictions within 8 inches in height of actuals.

	High water per cent.	Low water per cent.
Open coast stations	98	98
Riverain	48	47

281. The figures in the preceding paragraph and the tabulated statements from which they have been deduced give a very good idea of the correctness of the time predictions, but they scarcely show what percentages may be considered good as regards height, for although 98 would be a remarkably good percentage of predictions within 8 inches of height in the case of Amherst where the mean range at springs is over 20 feet, such a percentage could not be accepted as indicating that the height predictions were good in the case of Galle where the corresponding range barely exceeds 2 feet. There has therefore been added in the appendix a table of average errors in time in minutes, and of height in terms of the range, for the year 1886, which will enable a better estimate to be framed of the relative values of the predictions at the several tidal stations.

282. In addition to the usual tables showing the values of the tidal constants for the current year at the ports where observations are still being recorded, a first instalment of the completed tidal work is given this year. This is contained in tables Nos. 1 and 2, page xlii of the appendix, the first of which gives the values of the tidal constants for 12 stations at which observations have been completed, the second shows for the same ports the observed and theoretical values of the co-efficients in terms of the main lunar tide M_2.

283. For some years to come the number of tidal observatories is not likely to be reduced, and the ordinary computations connected with the reduction of the tidal registrations will continue to be carried on as at present. When the observatories become fewer the calculations of the meteorological corrections, and of the probable errors of the observations can be taken in hand, and will fully employ the computing staff of the party for many years.

SPIRIT-LEVELLING OPERATIONS.

284. The levelling operations during the year under report consisted of six sections as under:—(1) from Tuticorin to Madura, (2) from Madura to Trichinopoly and Tanjore to join the line executed in 1885-86, (3) from Trichinopoly to Erode to join the line executed in 1884-85, (4) from Shoranur to Cochin Tidal Station, (5) from Kárwár Tidal Station to Mormugáo Tidal Station, (6) from Agoada Fort Jetty to Agoada.

285. The total out-turn amounted to 450 miles of double levelling, in the course of which the heights of 418 permanent bench-marks and of 6 stations of the Great Trigonometrical Survey have been finally determined. The apparent mean generated error of levelling in the season's work was ·0008 foot per mile. The length of lines levelled fell short of last year's out-turn; this is accounted for by the nature of the country levelled over, which necessitated the instruments being set up at 332 extra stations: the total rise and fall in this year's work exceeded last year's by 6,741 feet. The heights of two stations on the South Konkan Series were also determined by levelling, and the data necessary for the revision of the heights of that series thus completed.

286. Three more pairs of test bench-marks for detection of secular change of relative level between land and sea by periodic determinations thereof, have been laid down in connection with the tidal stations of Mormugáo, Kárwár and Cochin.

287. It is intended in the ensuing season to undertake a line of levels between Madras and Vizagapatam in continuation of the general scheme of the Levelling operations.*

GEOGRAPHICAL SURVEYS.

UPPER BURMA.

288. During the year under report the detachment under Captain (now Major) Hobday was brought up to the strength shown in the margin and has been employed almost entirely on reconnaissance surveys in connection with the various military movements undertaken for the pacification of the country. In July 1887, Captain Hobday was forced to take privilege leave to recruit his health which had suffered much by his incessant work in unhealthy parts, and during his absence Lieutenant Jackson held charge of the party.

Personnel.

Major J. R. Hobday, B.S.C., Deputy Superintendent, 4th grade, in charge.
Lieutenant H. M. Jackson, R.E., Officiating Deputy Superintendent, 4th grade.
Mr. A. G. Wyatt, Surveyor, 3rd grade, from 1st January 1887.
Mr. F. Kitchen, Surveyor, 4th grade.
„ R.A. Gibson, Assistant Surveyor, 1st grade, from 17th November 1886.
Mr. J. M. Kennedy, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Mr. J. Macollough, Sher Shah, Faida Ali, Gobardhan Dass, Shib Charan, Sharf-ud-din, Mahomed Latif, Mahomed Ibrahim.

289. The operations of the various sections are as follows :—

In November Captain Hobday and a Sub-Surveyor accompanied a column which proceeded from Mandalay to Thonze *vid* Pyin-ul-win, and returned by the same route. In January Captain Hobday joined another expedition from Mandalay to the Shan State of Mainlon, *vid* Lamaing and Kalagwe and then proceeded with the troops to the Ruby Mines, returning from Mogok (the ruby-mining centre) to Thabeit-kyun on the Irrawaddy. In March Captain Hobday took advantage of the return of the Tsawbwa of Thibaw from Mandalay to his capital, under escort, and accompanied the party which travelled through Nammaw and Goteik to Thibaw. During a halt there he was enabled to explore the surrounding country. During these various expeditions the area reconnoitred and mapped in the Northern Shan States and in the Ruby Mines district amounts to about 3,000 square miles. An extract from Captain Hobday's report on the country passed through will be found at page lxxvi of the appendix.

290. During the early part of the season Lieutenant Jackson was employed in extending the regular triangulation from Myingyan on the Irrawaddy in a south-easterly direction to Hlaindet, a distance of about 75 miles: on completing this he joined a military expedition to Nyaungywe, now called Fort Stedman, in the Southern Shan States. From thence he accompanied various expeditions to Hopon, Meinpon, Mone, Maukme and Yatsauk, returning eventually to Mandalay by Kyaukse. His out-turn, together with that of the Sub-Surveyor who was attached to his party, was about 3,000 square miles of reconnaissance survey. An account of his operations also is given in the appendix, page lxxviii.

291. Mr. Wyatt and 3 Sub-Surveyors who were transferred from No. 20 Party on the suspension of the operations in the Prome district, were attached to the 3rd Brigade in the Mehtila and Yemethin districts and surveyed an area of 2,000 square miles, whereby a very useful map for the use of the brigade was compiled. Mr. Kitchen and a Sub-Surveyor accompanied the column which proceeded from Pagan on the Irrawaddy into the Yaw country. Mr. Kennedy extended the triangulation northwards to Kyan Nayat on the Irrawaddy and accompanied the expedition to the Ruby Mines.

* Major Hill reports very favourably of Messrs. Belcham and Connor in the Tidal Division and of Mr. Corkery and Sub-Surveyor Nursing Das in the Levelling Division. Sub-Surveyor Dhondu Venayek is also specially mentioned and Major Hill expresses himself well satisfied with the recorders and computers.

292. The result of the labours of these officers is as follows:—

Triangulation has been effected over an area of 15,000 square miles and the out-turn of reconnaissance surveys amounts to 11,000 square miles on the scale of 4 miles = 1 inch in the following States and districts—

	Square miles.
In Northern Shan States and Ruby Mines district	3,000
„ Southern Shan States	3,000
„ Yemethin and Mehtila districts	2,000
„ Yaw country	1,000
„ Mandalay and Kyaukse districts	2,000

293. A survey of the ruins of old Pagan, on the scale of 6 inches = 1 mile, was undertaken at the special request of the Chief Commissioner and completed during the recess season. Lieutenant Jackson, under whose direction this survey was executed, has submitted a report on the old Pagodas of Pagan which will be found in the appendix. He has also made a few sketches of some of the more artistic specimens which however he has not been able to complete at present. Captain Hobday recommends that an archæological expert should be sent to draw large plans and elevations of the ruins of peculiar interest.

294. In addition to the general geographical survey of the country, a survey of the town of Mandalay, on the scale of 40 feet to the inch, has been in progress since November 1886. This was urgently called for by the Deputy Commissioner of Mandalay to assist him in the demarcation of holdings, assessment of lands, &c., in the thickly populated portions of the town. The services of Mr. Gibson and 2 Sub-Surveyors were, therefore, placed at the disposal of the Local Government for this purpose and the work has been nearly completed, but the deputation of Mr. Gibson has been further extended for the purpose of surveying the area included within the embankment surrounding the town of Mandalay on the scale of 16 inches = 1 mile.

295. The compilation and incorporation into the work of the Survey Department of the independent reconnaissance sketches of military officers and of native soldiers who have passed the survey course at Roorkee, has continued to be one of the duties of Captain Hobday and his staff which has occupied a considerable portion of their time, but the additional information thus obtained has been of great value to military movements and to the object of obtaining some knowledge of the geography of tracts which in the ordinary process of survey operations with the limited staff of the professional department would take considerable time to evolve.

296. Captain Hobday reports that the difficulties in geographical survey in Upper Burma are very great owing to the dense forests, undergrowth, and high grass met almost everywhere, which impede the view and delay the progress of the operations. In March the undergrowth either dies or is burnt and then an impenetrable haze pervades the atmosphere till the commencement of the rains. These drawbacks, coupled with the necessity of keeping up with troops marching from 10 to 15 miles a day, render the carrying on of a connected triangulation and topography a matter of great difficulty, and Captain Hobday and his assistants deserve great credit for the large amount of valuable work which they have thus furnished. Captain Hobday's services were brought to notice by the General Officer Commanding the Upper Burma Field Force in his despatches to the Government of India and in recognition of those services he has received a Brevet Majority. His Excellency the Commander-in-Chief in India has also been pleased to express his appreciation of the work done in Upper Burma by the Survey Department, which was conveyed in the following terms in a letter from the Quarter Master General in India:—

"I am desired by the Commander-in-Chief in India to express His Excellency's appreciation of the important work carried out in Upper Burma by the Survey Department under Captain J. R. Hobday during the past eighteen months.

"2. In doing this I am to remark as follows:—

"For the first time during military operations in the field, the Survey Department, working in association with the Intelligence Branch of the Quarter Master General's Department, has been able to make full use of the reconnaissance sketches and reports prepared by military officers during movements against the enemy; it has further had placed at its disposal the information obtained from maps of the country prepared by Burmese draftsmen and has received the sketches and reports of trained Military Intelligencers belonging to the Native Army who have been trained at Roorkee.

"3. The compiled maps, which have been produced from time to time, have been of great value and may be regarded as the outcome of a satisfactory system under which no method of gaining topographical information has been overlooked. The rapid production of new maps for issue to officers commanding troops in the field, and the correction of old ones with the idea of facilitating military movements, have been successfully accomplished, in addition to the completion of a ½-inch map of the entire Province.

"4. Sir Frederick Roberts attributes the success which has attended this work very largely to the efforts of Captain J. R. Hobday and Captain E. W. Dun, Deputy Assistant Quarter Master General in charge of the Intelligence Office at Mandalay, and of the officers and subordinates who have assisted them; he, however, recognises the fact that the appreciation of experience gained during the Afghan war has, during recent operations in Burma, been very happily applied, so as to render the work of the Survey Department of immediate importance to the Commanding General in the conduct of difficult movements.

"5. I am to request that an expression of His Excellency's approval may be communicated to Captain Hobday and those serving under his orders."

297. This detachment has now been absorbed by No. 21 Party which has been transferred from the Nicobars to Upper Burma and placed under Major Hobday's charge. During the next season, the general reconnaissance surveys of the country will be continued and advantage will be taken of opportunities afforded by the military expeditions proceeding to unexplored parts.*

KUBO VALLEY DETACHMENT.

298. It having been decided that during the cold weather of 1886-87 a military column should proceed from Assam *vid* Manipur into the Chindwin Valley to co-operate with the field force in Upper Burma, it was considered desirable that a small survey party should accompany the column, as a great deal of the country that would be traversed was entirely unknown. Colonel Woodthorpe, who had but just returned from Gilgit, where he had been for more than a year with Colonel Lockhart's Mission, at once volunteered for the charge of this party, and his services were gladly availed of. He selected as his assistant Mr. Ogle, who had previously accompanied him in various adventurous expeditions on the north-east frontier; Sub-Surveyor Bapu Jadu and Sowar Kishen Sing, who had accompanied Colonel Woodthorpe throughout the Gilgit Mission and had done excellent survey work therewith, were also attached.

Personnel.

Colonel R. G. Woodthorpe, R.E., Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. M. J. Ogle, Surveyor, 2nd grade.
Sub-Surveyor Bapu Jadu, and Sowar Kishen Sing, 13th Bengal Lancers.

299. Leaving Calcutta on the 13th November, the party proceeded to Silchar in Assam where a short halt was made to complete arrangements for the advance. Manipur was reached on the 8th December, and the party separated on the 13th—Colonel Woodthorpe and Mr. Ogle to undertake the triangulation in extension of the surveys executed in Manipur in 1881-82, and the Sub-Surveyor to continue the said survey southward in Manipur and also to embrace the Kubo valley.

300. Towards the end of January this survey was almost finished, so leaving Mr. Ogle to complete what remained of the triangulation and topography and sending the Sub-Surveyor to survey the course of the Yu river from Tammu to its junction with the Chindwin with the aid of a subtense compass, Colonel Woodthorpe crossed the Angoching range with General Gordon who was in command of the column, and proceeded to Auktaung on the Chindwin river. Here he met Lieutenant Daly, and during the next month Colonel Woodthorpe accompanied that officer on his tours about the Lekayain district of which he was in political charge. A large amount of topography was thus obtained.

301. At the end of February the party re-assembled at Kendat and measures were taken for carrying the triangulation down the Chindwin river to Alon, whence

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* Of his Assistants Captain Hobday reports as follows:—"The out-turn completed by Lieutenant Jackson is a highly creditable performance and I can testify to his untiring zeal and ability. Brigadier-General Lockhart, C.B., has expressed his acknowledgment of the valuable services rendered by Mr. Wyatt and his assistants. Major Stead, Commanding the Yaw column, reported favourably on the assistance given him by Mr. Kitchen. Mr. Gibson is a most valuable assistant; he possesses ability and tact and is an indefatigable workman; Mr. Bridges, Deputy Commissioner, Mandalay, speaks highly of his services. Mr. Kennedy has worked well and is I consider a very promising officer. Of the Sub-Surveyors, Faida Ali, Sher Shah, and Shiv Charan are deserving of special mention."

a junction might be effected with the Mandalay triangulation. These operations were somewhat delayed by a disturbance occurring in the Mingin district early in March, which rendered it necessary to recall all detached parties. By the middle of March, however, the country was quiet again and the triangulation was continued.

302. While Mr. Ogle and the Sub-Surveyor were engaged on this triangulation, Colonel Woodthorpe accompanied Captain Raikes, Deputy Commissioner of the Chindwin district, to Indin, about 35 miles to the west of Mingin, on a visit to the Tsawbwa of Kale, who wished to tender his submission to the British Government. The journey to Indin and the halt there during the negotiations enabled Colonel Woodthorpe to survey a good deal of the Myittha river and to obtain a fair amount of topography in the valley, though the smoke of the jungle fires and hazy state of the atmosphere prevented as much being done as might have been expected under more favourable circumstances. On his return from this trip, Colonel Woodthorpe rejoined Mr. Ogle, and they conjointly continued the triangulation which was completed as far as Alon by the end of April. Colonel Woodthorpe was then prostrated by fever which lasted during the whole of May, but Mr. Ogle with his usual energy continued the triangulation and effected a junction with Captain Hobday's series, brought up from Mandalay. The result of the junction is found not to be entirely satisfactory; but considering the difficulties under which the operations from both sides have been carried on, this is not surprising. During the ensuing season a further connection will be made, and it is hoped that the errors may thus be localised and the work adjusted.

303. Observations for latitude were taken at Kalewa, Mingin and Alon, and their positions thus determined agree fairly well with those obtained by the triangulation. At Alon an azimuth was observed to Shwe-ta-u *pagoda* and the result was again fairly accordant with that of the triangulation.

304. The results of the season's operations are as follows:—

An area of 2,800 square miles was triangulated; 360 square miles of country were surveyed topographically on the $\frac{1}{2}$-inch scale in the south-east of Manipur in continuation of the survey of 1881-82; the whole of the Kubo valley and a large portion of the Lekayain district, comprising an area of 3,924 square miles, was surveyed on the $\frac{1}{4}$-inch scale, and an accurate map was obtained of the course of the Chindwin river between the point where the Uyu or Uru river joins it and Monyua.

In recognition of his services in Burma, Colonel Woodthorpe has been appointed to be a Companion of the Order of the Bath.

305. The party returned *viâ* Rangoon and Calcutta and reached Shillong, their recess quarters, on the 17th July 1887.

306. Colonel Woodthorpe reports that he received the most cordial assistance from all officers, both civil and military, with whom his work brought him into contact. Extracts from Colonel Woodthorpe's narrative report regarding the country passed through will be found in the appendix, page lxxxii.*

TRANS-HIMALAYAN EXPLORATIONS.

BHUTAN AND TIBET.

307. The report on the explorations of M—H, referred to in paragraph 266 of the last Annual Report, has been published during the year. It is accompanied by a sketch map, and besides tracing the Dudhkosi to its source, it supplies a long existing *desideratum* in the geography of Tibet, between Dingri, Jongkhajong and Kirong, and furnishes new information as to the course of the Gandak above Tirbenighat.

308. The detailed report and map of explorer R. N.'s work, also referred to in the last Annual Report (paragraph 267), are still unfinished, but a condensed

* Colonel Woodthorpe reports that Mr. Ogle sustained his high reputation as an accomplished surveyor, that Sub-Surveyor Bapu Jadu worked well and fully justified the high opinion that had previously been formed of him.

account by Colonel Tanner will be found in the appendix, accompanied by a sketch map of Bhutan, which, it is believed, will be very acceptable to geographers, as it embodies all the information available up to date regarding that little known country.

309. A new sketch map of the lower Sangpo and adjoining regions has been compiled by Colonel Tanner from the late Captain Harman's plane-table sections of the country round Sadiya in conjunction with the information furnished by K. P., who was sent by that officer in 1880 to explore the great river below Gyala Sindong. This man accompanied a Chinese *lama* as an assistant, and besides being ordered to explore the country between the most extreme point reached by explorer G. M. N. and Assam, they were instructed to throw marked logs into the Sangpo at the lowest point reached in their travels, so that watchers having been placed at the point where the Dihang debouches into Assam, the identity or otherwise of the great river of Tibet with the Dihang might be determined. The *lama* having sold K. P. as a slave in the Pemakoi country, decamped, and the latter after various wanderings returned to Sikhim last year.

310. A succinct account of the information brought back by K. P. is included in the notes by Colonel Tanner which are given in the appendix. K. P. states that he went down the Sangpo as far as Onlet in the country of the Lo people, about 35 miles from the British boundary, and saw Miri Padam, the abode of the Miris and Abors, about 12 miles down the river and beyond this the haze of the plains of India. He states that below Gyala Sindong the Sangpo flows south and making a little westing turns by a gradual bend nearly eastward from Miri Padam, in which direction it emerges from the hills into Assam. This course agrees with the approximate course given on one of the late Captain Harman's plane-table sections, on which a large river is shown coming in from the north-east at a point some 50 miles west and a little north of the gorge through which the Dihang enters Assam. This large feeder is assumed to be A—K's Nagong Chhu and is taken to be identical with K. P.'s Yangsong or Zyul Chhu, which he states drains Zyul Ted or Upper Zyul. Below Gyala is a country called Pemakoichhen inhabited by the Chingmis, who were met by R. N. in Bhutan. A few miles below Pema Koichung are the great falls of the Sangpo where the river descends over a cliff of about 150 feet into a deep basin above which K. P. noted the rainbows caused by the spray of the cataract.

311. The Chingmis extend to Dangam at the junction of the Lo river with the Sangpo, below which Tibetan names and influence cease. At this place commences the country of the three tribes of aborigines called collectively Lo Kabta, who are divided into sections named Lo Nakpo, Lo Karpo and Lo Tawa Lo means "barbarous" in Tibetan and is not to be confused with A—K' Lho. which means "south." These people occupy a pleasant tract, having brought the lands on either side of the Sangpo into a high state of cultivation, and mangoes, plantains and oranges thrive. They are averse to anything which savours of Buddhism or to Tibetan habits; they are great hunters and shoot, either with bows and arrows or with matchlocks, the bison and other game which is found in plenty on the mountain slopes. From Gyala Sindong downwards the river is enclosed by snow-clad mountains on which the wild *yak* and *shao* or Tibetan stag abound. The Padams are known to us (on the authority of Mr. Needham) as Abors. K. P. has given a short vocabulary of the language of the Chingmis and also of the Lo and Po countries.

It is intended to publish as early as convenient a complete report including the itineraries and narratives of R. N. and K. P. as well as a short account of the Pemakoichhen country by Lama U. G. from information furnished by the Mongolian *lama* Serap Gyatsho.

312. In addition to the work noticed in the foregoing, an extensive exploration by Mr. Dalgleish in Eastern Turkestan and Mongolia was examined and a preliminary adjustment made of the route, a copy of which was supplied to Mr. Carey. This route extends over 3,000 miles of ground, and, as it is well checked by latitude observations as well as by the work of both A—K and Prejevalsky, which it strikes at more than one point, it is undoubtedly a valuable addition to our previous knowledge of the tract through which it passes. The account of Mr. Carey's remarkable journey will be found in the Proceedings of the Roval Geographical Society, December 1887.

Summary of the Out-turn of Work of the

Scale of Survey.	Number of Party.	Locale of Field Operations.	TRIANGULATION.																		Number of extra heights determined.	
			Instrument used.	Area triangulated in square miles.	Number of Stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Secondary—in which each angle is usually observed on two zeros.					Tertiary—in which two angles of each triangle are observed.									
								Number of Stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.						
50 feet=1 inch	...	Town of Calcutta	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...				1	
16 inches=1 mile	2	Bilaspur and Raipur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	3	Raipur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	4	Basti	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	5	Gorakhpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...				5	
	,,	Tarai	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	6	Darrang and Nowgong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	7	Akyab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	,,	Bassein																				
	8	Sankarpur, Dinagepore	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	,,	Angul, Orissa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...				10	
	9	Jubbulpore and Damoh	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	11	Seoni and Chhindwara	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	12	Saugor and Narsinghpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	13	Sambalpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	14	Mirzapur	7″	...	...	...	...	...	...	...	...	...	...	...	...	...	...				15	
8 inches=1 mile	5	Gorakhpur (Forests)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	10	Belgaum ,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	17	Thana ,,	5″, 6″, 7″, 8″	107	145	0·2	0·2	132	158	5·9	0·50	159	416	686	0·8	396	493					
6 inches=1 mile	1	Gurdaspur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	16	Baluchistan	8″	40	16	0·6	0·6	14	24	10·0	0·18	13	53	109	0·3	...	54				20	
4 inches=1 mile	4	Gorakhpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	18	Himalayas	5″, 6″, 7″, 12″	883	334	1·0	1·2	334	301	17·0	1·10	285	530	750	1·6	463	629					
	20	Lower Burma (Forests)	8″, 5″	295	12	22·7	29·5	10	15	7·2	0·30	10	1	1	...	...	...					
	21	Nicobar Islands	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
2 inches=1 mile	1	Punjab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...				25	
	7	Akyab and Bassein	12″	167	7	17·0	24·0	5	7	18·0	0·01	3	14	18	1·7	5	651					
	10	South Maratha Country	5″, 6″, 7″	1,570	150	10·4	8·3	150	267	16·5	0·69	150	...	...	...	...	40					
	14	Mirzapur	12″, 7″	525	31	2·4	2·5	24	57	14·0	0·40	24	194	348	1·2	183	...					
	16	Baluchistan	7″, 6″	910	56	2·1	2·6	46	115	11·4	0·26	33	318	613	0·5	280	...					
	17	Gujarat	10″, 6″	1,085	89	1·5	1·6	66	231	2·6	0·37	87	676	1,352	1·2	600	94				30	
	18	Himalayas	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
1 inch=1 mile	7	Akyab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
	19	Madras	12″, 8″	4,370	69	6·2	6·4	57	140	11·0	0·30	57	691	1,224	0·7	649	...					
½-inch=1 mile	15	Baluchistan	6″	8,500	49	13·5	14·2	49	91	7·0	0·50	49	580	679	1·5	550	2					
	16	Ditto	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...				35	
	21	Nicobar Islands	14″, 6″	(*f*)	27	(*f*)	(*f*)	27	40	5·0	0·70	24	66	120	1·7	25	...					
	24	Madras Coast	12″	1,162	60	18·0	20·0	57	19	5·0	0·20	62	13	18	0·2	3	...					
	25	Madras and Bombay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
⅓- and ¼-inch=1 mile	Detachment.	Kubo Valley, &c.(*h*)	6″	2,800	56	...	...	56	91	14·1	0·50	54	63	119	2·1	51	...					
¼-inch=1 mile	Ditto	Upper Burma (*h*)	...	15,000	...	...	...	...	...	...	...	...	...	...	...	...	...				40	

Field Parties during the year 1886-87.

	SPIRIT LEVELLING OPERATIONS.				TRAVERSING.					TOPOGRAPHY.							REMARKS.
	Number of miles levelled over.	Number of permanent bench-mark stones embedded.	Number of Trigonometrical stations connected with lines of level.	Number of permanent points fixed as bench-marks.	Number of stations at which theodolite was set up.	Linear miles.	Average angular error per station in seconds.	Average error per *mille* in links.	Square miles of village survey.	Area in square miles.	Average number of plane-table fixings per square mile.	Number of linear miles of test lines.	Number of villages.	Number of fields.	Average size of fields in acres.		
1	...	...	...	...	...	...	...	...	...	2·2	...	...	...	4,315(*a*)	0·33(*a*)		(*a*) Holdings.
	...	...	...	...	12,836	3,808	2	0·3	1,233	1,022	...	1,700	697	9,36,887	0·40(*b*)		(*b*) Calculated on cultivated portions only.
	...	...	...	...	29,030	7,509	4	0·4	3,150	...	...	...	1,445	...	...		(*c*) Includes survey of village and forest boundaries.
	...	...	...	...	4,009	1,860	3	0·2	567	774	...	2,337	1,956	18,47,354	0·27		
5	...	...	...	...	23,212	3,863	2	0·1	1,179	1,048	...	2,771	1,685	9,30,427	0·72		(*d*) Area tested only and maps compiled from *patwari* survey.
	...	...	...	...	2,048	394	...	...	76	76	...	360	60	31,078	1·57		
	...	...	...	...	7,113	1,611	3	0·3	456	547	...	1,156	630	2,41,617	1·45		(*e*) Includes 236 miles boundary survey.
	...	...	...	...	8,737	1,688	1	0·1	562	350	...	504	134	4,35,198	0·22(*b*)		(*f*) A large expanse of the sea being covered by the triangulation in passing from island to island, any statement of area would mislead. The area of the whole group of Nicobars is 678 square miles.
										196	...	270	82	73,600	0·67(*b*)		
	...	...	...	...	...	...	...	...	199	199	...	...	532	1,24,833	1·02		
10	...	...	...	...	...	...	...	...	61	61	...	...	83	50,000	0·78		
	...	...	...	...	46,918	8,019	...	...	2,590	...	...	...	1,577	...	...		(*g*) Chiefly reconnaissance; 10 latitudes and 2 azimuths by astronomical observations, and 2 chronometric longitudes were also determined.
	...	...	...	...	32,432	5,810	5	0·3	2,312	...	...	...	1,049	...	...		
	...	...	...	...	30,056	5,100	4	0·4	1,555	...	...	...	966	...	...		
	...	...	...	...	10,404	2,808	5	0·3	969	...	...	...	469	...	...		
15	...	...	...	...	4,105	860	7·5	0·8	...	...	...	...	536	...	...		(*h*) Reconnaissance surveys.
	...	...	...	...	...	...	...	...	...	28	...	...	...	...	...		
	...	...	...	...	8,623	862	8	0·8	215 (*c*)	...	...	...	...	...	...		
	...	...	...	...	1,722	159	16	2·9	...	53	203	...	...	...	...		
	...	...	...	...	...	...	...	...	...	45	...	...	...	...	...		
20	...	...	...	...	...	...	...	...	...	27	161	...	...	...	...		
	...	...	...	...	...	...	...	...	...	72	...	...	...	...	...		
	...	...	...	...	2,012	523	26	0·9	...	272	40	...	...	...	...		
	...	...	...	...	5,573	3,871	6·3	3·4	...	46	290	9·8	...	...	...		
	...	...	...	...	...	...	...	...	...	6	138	6·6	...	...	...		
25	...	...	...	...	17,757	7,914	2	...	6,085	2,726(*d*)	...	...	...	...	...		
	...	...	...	...	...	...	...	...	...	539	...	...	...	...	...		
	...	...	...	...	2,094	1,088	5	0·6	...	1,412	16	76	...	...	...		
	...	...	...	...	...	...	...	...	...	454	...	...	...	...	...		
	...	...	...	...	...	...	...	...	...	760	22	...	...	...	...		
30	...	...	...	...	1,166	433(*e*)	19	0·7	...	1,841	22	309	...	...	...		
	...	...	...	...	...	...	...	...	...	35	29	...	...	...	...		
	...	...	...	...	...	...	...	...	...	85	...	...	...	...	...		
	...	...	...	...	...	...	...	...	...	172	2·0	...	...	...	...		
	...	...	...	...	...	...	...	...	...	8,832	1·2	...	...	...	...		
35	...	...	...	...	...	...	...	...	...	2,276	1·7	...	...	...	...		
	...	...	...	...	1,272	434	...	4·6	...	678(*g*)	...	...	...	...	...		
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	450	44	6	373	...	...	...	...	...	...	...	...	...	...	...		
	...	...	...	...	...	...	...	...	...	4,284	0·1	...	...	...	...		
40	...	...	...	...	...	...	...	...	...	11,000	...	...	...	...	...		

Statement showing the Cost-rates of work executed by the

Number of Party.	Nature and *locale* of Field Operations.	Cost-rate per square mile in Rupees.									
		Triangulation.	Traversing.	Detail Survey on Scales of							
				½″	1″	2″	4″	6″	8″	16″	105·6″
	Topographical Surveys.										
10	South Maratha Country	3·5	6·8	...	...	7·7	...	...	...	...	...
14	Mirzapur	15·0	...	...	...	80·1	...	...	...	...	...
15	Baluchistan	2·8	...	6·5	...	...	...	...	...	...	...
16	Baluchistan	149·8	...	...	...	...	...	329	...	...	...
		19·4	...	...	...	42·1	...	...			
		...	...	4·9	...	...	...	...			
17	Gujarát	8·7	5·4(*c*)	...	...	23·5	...	...	...	...	...
18	Himalayas	28·0	23·7(*d*)	...	...	106·2	421·3	...	...	...	...
19	Madras	80·9	...	...	16	...	...	...	...	...	...
	Forest Surveys.										
10	Belgaum	...	118·2(*f*)	...	...	...	...	...	...	...	...
17	Thana	85·5		...	...	...	...	...	206·6	...	...
	Cadastral Surveys.										
2	Bilaspur and Raipur	...	18·9	...	...	...	...	...	...	58·3	...
4	Basti	...	27·3	...	...	...	...	...	...	94·8	...
5	Gorakhpur	...	20·2	...	...	...	...	...	...	60·2	...
	Tarai	...	38·1	...	...	...	...	...	...	36·0	...
6	Darrang and Nowgong	...	35·3	...	...	...	...	...	...	96·1	...
7	Akyab and Bassein	...	95·8	...	...	47·0 (*m*)	...	...	...	185·9	...
8	Sankarpur Estate, Dinagepore	...	58·1	...	...	...	...	...	...	113·6	...
	Angul, Orissa	...	42·3	...	...	...	...	...	...	131·2	...
	Traverse Surveys.										
1	Punjab	...	6·1(*r*)	...	...	7·3(*s*)	...	46·4	...	...	...
3	Raipur	...	19·7	...	...	...	...	...	...	...	...
9	Jubbulpore and Damoh	...	23·5	...	...	...	...	...	...	...	...
11	Seoni and Chhindwara	...	29·2	...	...	...	...	...	...	...	...
12	Saugor and Narsinghpur	...	37·4	...	...	...	...	...	...	...	...
13	Sambalpur	...	36·2	...	...	...	...	...	...	...	...
	City Survey.										
8	Calcutta	...	1,352·2	...	...	...	...	...	...	...	12,549·9

several Field Parties during the year 1886-87.

Rate in annas for traversing, detail survey, and preparation of maps.		Cost-Rates.					Total cost.	Remarks.
Scale 16″ = 1 mile.		Stone embedding.	Records (Khanapuri).		Completion of Vernacular Records, Assessment Statistics, &c.			
Per acre.	Per field.	Per square mile.	Per square mile.	Per field.	Per square mile.	Per field.		
a. *p.*	*a.* *p.*	*R*	*R*	*a.* *p.*	*R*	*a.* *p.*	*R*	
...	...	...	...	...	...	...	25,422 (*a*)	(*a*) Includes R192 expended on drawing 4″ maps of District Thana.
...	...	...	...	...	...	...	63,087 (*b*)	(*b*) Includes R11,705 on account of traversing for Cadastral Survey of Chakia estate, R6,762 for compilation of the Jhadohi maps and R383 on account of the Dudhi Survey.
...	...	...	...	...	...	...	84,776	(*c*) Per linear mile; Baroda State boundary traverse.
...	..	...	...	...	...	...	77,531	(*d*) Per linear mile; executed for subsequent Settlement Surveys.
...	...	...	...	...	...	...	54,031	(*e*) Includes R500 for mapping of Daling Survey.
...	...	...	...	...	...	...	74,770 (*e*)	(*f*) Includes the survey of village and forest boundaries.
...	...	...	...	...	...	...	50,255	(*g*) Includes the completion of vernacular records, assessment statistics, &c.
...	...	...	...	...	...	...	25,421	(*h*) Includes R6,034 expended on 2″ and 4″ mapping and R480 for instruction of junior Civilians and *patwáris*.
...	...	...	...	...	...	...	20,098	(*i*) Includes R408 expended on the survey of 28 square miles of forests on the 8″ scale, R392 for instruction of junior Civilians, R1,660 expended on 2″ and 4″ mapping.
								(*k*) Includes R3,016 for instruction of *patwáris* and payments to substitutes for doing their district duties.
1 11	1 4	1·4	54·3 (*g*)	0 11	...	...	1,46,546	(*l*) Includes R801 expended on revision work and R2,819 on 2″ mapping.
3 6	0 11	6·4	43·4	0 3	65·8	0 5	1,83,625 (*h*)	(*m*) Includes cost of 85 square miles on 1″ scale.
2 1	1 6	6·7	23·9	0 5	30·6	0 6	1 54,441 (*i*)	(*n*) Includes R1,665 expended on revision work.
1 10	2 10	4·4	...	...	20·4	0 9	10,579 (*k*)	(*o*) Includes R1,533 expended on traverse work and Survey School in Maldwar estate.
3 3	4 8	...	50·1	1 10	17·4	0 5	1,69,235 (*l*)	(*p*) Includes R8,308 expended on Mozaffer-pore records, and R4,378 on Survey Schools at Angul and Banki.
7 1	4 9	...	...	...	...	...	1,90,889 (*n*)	(*r*) Traversing limited to fixing village boundary trijunction marks.
4 4	4 5	1·6	57·8	1 5	22·3	0 7	54,714 (*o*)	(*s*) Topography not surveyed but obtained by reduction from Settlement Survey maps; the reduced maps are tested.
4 5	3 5	2·9	36·2	0 8	20·4	0 5	40,153 (*p*)	(*t*) Includes R583 expended on 4″ mapping in District Rawalpindi; R846 on survey of boundary between District Dera Ghazi Khan and Bahawalpur State; R509 on records for Settlement Department, Hissar; and R1,818 on traversing and mapping in Sikh States.
...	...	...	...	...	...	...	62,392 (*t*)	
...	...	...	...	...	...	...	62,115	
...	...	2·5	...	...	...	...	67,338	(*v*) Includes R5,076, pay of establishment before field work began; R864, pay of computers employed on other work; R900, pay of officer on sick leave; R801, cost of 11,803 mark-stones paid for in advance.
...	...	...	...	...	...	...	67,408	
...	...	3·5	...	...	...	...	71,214 (*v*)	
...	...	...	...	...	...	...	35,089	
	Per holding							
R *a.* *p.*	*R* *a.* *p.*							
21 8 10	7 1 9	...	...	...	...	...	38,277	

Tabulated Statement of the principal Records prepared in the several Recess Offices of the Field Parties of the Revenue Branch for the year 1886-87.

Number of Party.	Nature of Survey and Locality.	Mapping.						Traverses.		Field Books.		Area Books.		For Settlement Department.		Remarks.
		Original field Sections.	Cadastral 16-inch sheets.	Sheets, 4-inches = 1 mile $7\frac{1}{2}' \times 3\frac{3}{4}'$.	Quarter sheets, 2 inches = 1 mile $15' \times 7\frac{1}{2}'$.	Index Maps.	Triangulation Charts.	Main circuit with azimuth computations. Vols.	Village or sub-circuits. Vols.	Main circuit. Vols.	Village or sub-circuits. Vols.	Villages.	Fields.	Sheets or tracings.	Village registers (khasras).	
	Cadastral Surveys.															
	North-Western Provinces.															
4	Basti	12 on 64″ 1,523 on 16″	12 on 64″ 1,523	...	21	1	...	1 1 Az.	2	1	4	1,956	1,847,343	3,912	1,956	Besides the *khasras* the records prepared for Settlement Department are, Urdu *khasra* with 2 dispute lists, *jamabandi* slips, book *jamabandi*, *patwári* serial list, *terij*, caste statement, soil statement, crop statement, agricultural statistics and English village assessment statement with details of soils, crops and castes.
5	Gorakhpur	1,976 on 16″ 11 on 8″ 8 on 4″ 3 on 2″	1,976	11 on 8″ 8 on 4″ 3 on 2″	...	2	...	1 1 Az.	8	1	20	1,695	930,427	3,390	1,695	The same as above. Eight skeleton quarter-sheets on 2-inch scale have been projected for the Surveyor General's Office, where the topographical maps are being drawn.
	Tarai	...	113	...	...	...	...	...	1	...	3	60	31,078	60	...	
	Central Provinces.															
2	Bi spur	694 on 16″	694	...	...	1	...	1 1 Az.	4	1	8	436	520,176	872	436	The *khasras* have been furnished in duplicate, and besides these the following other vernacular records have been furnished to the Settlement Department, all in duplicate, *viz.*, *khewat*, *jamabandi* slips, book *jamabandi*, abstract of the same and crop statement.
	Raipur	624 on 16″	624	...	..	1	...	1 1 Az.	1	1	2	342	556,764	684	342	In Pargana Khalari, District Raipur, 285 skeleton sheets have been plotted for Settlement Department.
	Bengal.															
8	Cuttack	110 on 16″	110	...	...	1	...	1	4	1	7	81	50,000	81	81	
	Dinagepore	477 on 16″	477	...	...	1	...	5	5	5	10	471	93,466	471	471	
	Assam.															
6	Darrang	718 on 16″	718	...	2	...	...	1	1	1	1	630	241,617	630	630	Besides these, the following records have been prepared for Settlement Department :— 202 *lakhiraj* and *nisfkhiraj* field area statements. 41 Waste Land Grant field area statements. 14 Jungle Section field area statements.
	Nowgong	...	...	...	10	1	...	1 1 Az.	2	1	2	...	...	...	...	

	Burma.															
7	Akyab	26 on 2″ 1 on 1″	477	1 on 1″	36	1	2	...	...	...	...	134	435,198	477	...	Besides the tracings of sheets, copies of the area books have been furnished to the Settlement Department.
	Bassein	...	267	...	...	1	...	1	1	2	3	82	73,600	267	...	
	Thongwa	...	...	...	...	...	...	...	1	...	2	...	...	...	...	
	TRAVERSE SURVEYS.															
	Central Provinces.		Skeleton Plots.													
3	Raipur	...	2,270	...	...	...	...	2	8	3	21	...	...	...	...	22 volumes of co-ordinates and area statements have been furnished to Settlement Department.
9	Damoh	...	4,303	...	...	1	...	1	6	3	7	...	...	...	...	11 volumes of co-ordinates and area statements have been furnished to the Settlement Department.
	Jubbulpore							1	6	2	7	...	...	...	...	
11	Chhindwara	...	1,024	...	...	10	...	2	5	1	5	...	...	...	...	
	Seoni	...	1,034	...	...	12	...	2	6	1	6	...	...	...	...	
12	Narsinghpur	...	505	...	...	...	...	1 1 Az.	6	2	11	...	...	...	...	
	Saugor	...	592	...	...	...	...	2 2 Az.	4	2	11	...	...	...	...	
13	Sambalpur	...	1,112	...	...	1	...	2	5	3	8	...	...	...	...	
	TOPOGRAPHICAL SURVEYS.															
	Punjab.															
1	Gujranwala, Gurdaspur, Shahpur, Hoshiarpur, Umballa, and Sikh States.	60 on 2″ 7½′×7½′	...	2 on 1″	34	2	...	3	4	4	12	...	...	...	...	212 index charts to 1,525 villages have been furnished to the Settlement Department.
	Bombay.															
10	Belgaum, Dharwar and Kaladgi	20 on 2″	...	64n	12	1	1	...	8	...	7	...	...	...	...	64 sheets on 8″ scale have been prepared for the Forest Department.
	CITY SURVEY.															
8	Calcutta	129 on 50 ft. =1 inch.	...	...	...	1	...	1	2	1	5	...	...	...	...	

Abstract of Out-turn and Cost of the Revenue Branch Parties according to Jurisdictions.

Provinces.	Scale of Survey.	Out-turn in square miles.	Cost.	Remarks.
			R	
N.-W. Provinces	16 inches = 1 mile	1,898	348,646	
	8 „ = 1 „	28		
	4 „ = 1 „	72		
Bengal	16 „ = 1 „	260	94,869	
	50 feet = 1 inch	2¼	38,277	
Punjab	2 inches = 1 mile	2,726(a)	62,392	(a) Topography tested only on maps compiled from the Settlement Survey maps.
	6 „ = 1 „	45		
Assam	16 „ = 1 „	547	1,09,235	
Lower Burma	16 „ = 1 „	536	1,90,889	
	2 „ = 1 „	539		
	1 „ = 1 „	85		
Bombay	8 „ = 1 „	215(b)	50,843	(b) Survey of forest and village boundaries without topography.
	2 „ = 1 „	1,412		
Central Provinces	16 „ = 1 „	1,022	1,46,516	
	16 „ = 1 „	10,576(c)	3,03,164	(c) Traverse survey skeleton maps are plotted on 16-inch scale.
Total		19,973¼	13,44,861	

PART III.

THE OPERATIONS AT THE HEAD-QUARTER OFFICES.

313. These offices comprise :—

(1) The Head-Quarter Offices at Calcutta.

(2) The Trigonometrical Branch Office at Dehra Dún.

There has been little or no change in the general administration of these offices, except that Lieutenant-Colonel R. Beavan, S.C., Officiating Assistant Surveyor General, proceeded on furlough in June 1887, when Major Baird, R.E., was appointed to fill the post temporarily.* The work in all the various offices is described below.

I.—HEAD-QUARTER OFFICES, CALCUTTA.

SUPERINTENDENCE, CORRESPONDENCE AND ACCOUNTS.

Personnel.

Colonel H. R. Thuillier, R.E., Surveyor General of India.
Colonel J. Sconce, S.C., Deputy Surveyor General, in charge Revenue Branch.
Colonel D. Macdonald, S.C., Deputy Superintendent, 1st grade, Assistant Surveyor General.
Lieutenant G. B. Hodgson, S.C., Officiating Deputy Superintendent, 4th grade, Personal Assistant to the Surveyor General.
Mr. T. W. Babonau, Registrar.

Correspondence.

Mr. M. Francis, Head clerk.
„ E. D. Algar, do.
„ J. A. Vallis, do.
„ T. E. Ware, clerk.

Babu Kally Podo Banerjee, clerk.
„ Banee Madhub Banerjee, „
„ Doorga Narain Ghose, „
Mr. H. R. D'Mello, „
Babu Ram Kristo Chunder, „
„ Bheecum Sing, „
„ Chuni Lall Dey, „
„ Gopal Chunder Dass „
„ Raj Coomar Dutt, „
And 14 others.

Accounts.

Mr. H. H. Fenwick, Head Accountant.
Babu Bama Churn Chuckerbutty, clerk.
„ Raj Krishna Mukerjee, „
And 5 others.

314. The Revenue Survey section of the office has been supervised by Colonel J. Sconce, Deputy Surveyor General, who has also carried on the duties connected with accounts as well as the correspondence of this branch. The duties of the General and Topographical sections were superintended by Colonel D. Macdonald, Assistant Surveyor General. Lieutenant G. B. Hodgson has continued to hold the post of Personal Assistant to the Surveyor General.*

DRAWING OFFICE.

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General, in charge up to 6th June 1887.
Major A. W. Baird, R.E., Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General from 7th June 1887.
Mr. G. A. McGill, Chief Draftsman.
„ P. J. W. Doran, Draftsman.
„ W. Green „
„ W. J. R. Adels „
„ A. J. Musgrove „
„ R. Sinclair „
„ A. S. Bateman „
„ G. Gill „
And two other Draftsmen.

Additional Establishment.

Mr. W. Stotesbury, Surveyor, 4th grade, Draftsman.
And seven other Draftsmen.

Native Draftsmen.

Munshi Sonaullah.
„ Nabi Buksh.
Babu Harihur Sen.
„ Mohesh Chunder Shaw.
Munshi Muttiullah.
Babu Purna Chunder Sen.
„ Gopal Chunder Roy.
And 36 others.

Surveyors and Assistant Surveyors on duty.

Mr. S. M. Smylie, Surveyor, 1st grade.
„ F. Adams „ 2nd „
„ S. O. Madras, Assistant Surveyor, 1st grade.
Mr. E. J. Martin, Assistant Surveyor, 1st grade.
Mr. W. H. Penrose, Assistant Surveyor, 1st grade, from 3rd February 1887 to 6th April 1887.
Mr. W. H. D. Ewing, Assistant Surveyor, 2nd grade, from 1st February 1887.
And one Sub-Surveyor.

315. Up to 6th June 1887 Colonel R. Beavan continued to act as Assistant Surveyor General in charge of the Drawing Office, and after that date Major A. W. Baird, R.E., has superintended it. The office is divided into three sections, which are described below and a statement in detail of the work executed in each section is given in the appendix.

* Colonel Macdonald reports as follows :—

Messrs. T. W. Babonau, M. Francis, H. H. Fenwick, and J. A. Vallis have all worked well and steadily and given entire satisfaction.

Babus Banee Madhub Banerjee, Doorga Narain Ghose, Bama Churn Chuckerbutty, Bheecum Sing, Chuni Lall Dey, Raj Krishna Mookerjee, Hem Nath Dutt, Khetter Mohun Dass, Kanty Chunder Sen, and the remaining clerks have been working very steadily.

The Deputy Surveyor General, Revenue Branch, names Mr. E. D. Algar and Babus Kali Podo Banerjee, Ram Kristo Chunder, and Raj Coomar Dutt as deserving of special mention.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

316. The urgent demand for maps of Afghanistan and Baluchistan as well as for compilations from rough military reconnaissances in Burma, in addition to all the regular routine work, has caused considerable pressure on this section. Most of the $\frac{1}{4}$-inch sheets of the Afghan Boundary work are being compiled under Major Gore's superintendence at Dehra, but some have been undertaken by this office. Of these two have been printed whilst two are in hand. In Baluchistan three new sheets on the $\frac{1}{4}$-inch scale have been drawn and published and one of the old sheets of Afghanistan has been redrawn. Of Burma, 14 sheets on the $\frac{1}{4}$-inch scale were prepared from route surveys and reconnaissances furnished by Major Hobday, and from these again a map of Upper Burma on the scale of 1-inch = 16 miles has been compiled. All these are as yet necessarily of a very sketchy description, but it is hoped that they will be soon superseded by more detailed maps.

317. A new edition of the 32-mile map of India is in progress; it is being prepared by transfers to stone from the copper-plates; the blank tracts as well as the trans-frontier countries are being filled up on the stone from the best available material. It is also contemplated to produce an outline map of India from these copper-plates by the electrotype process, a matrix being prepared from which the hills will be burnished out; after this has been done, duplicate copper-plates will be prepared by the same process and the damage done to the outline and writing in the course of the burnishing process will then be remedied and the plates completed by the engravers. Thus it is hoped that in a comparatively short time and with a minimum amount of skilled labour a first-rate map of India without hills will be obtained. It is believed that such a map will be largely used for representing lines of railway, canals, telegraphs, postal communications, &c.

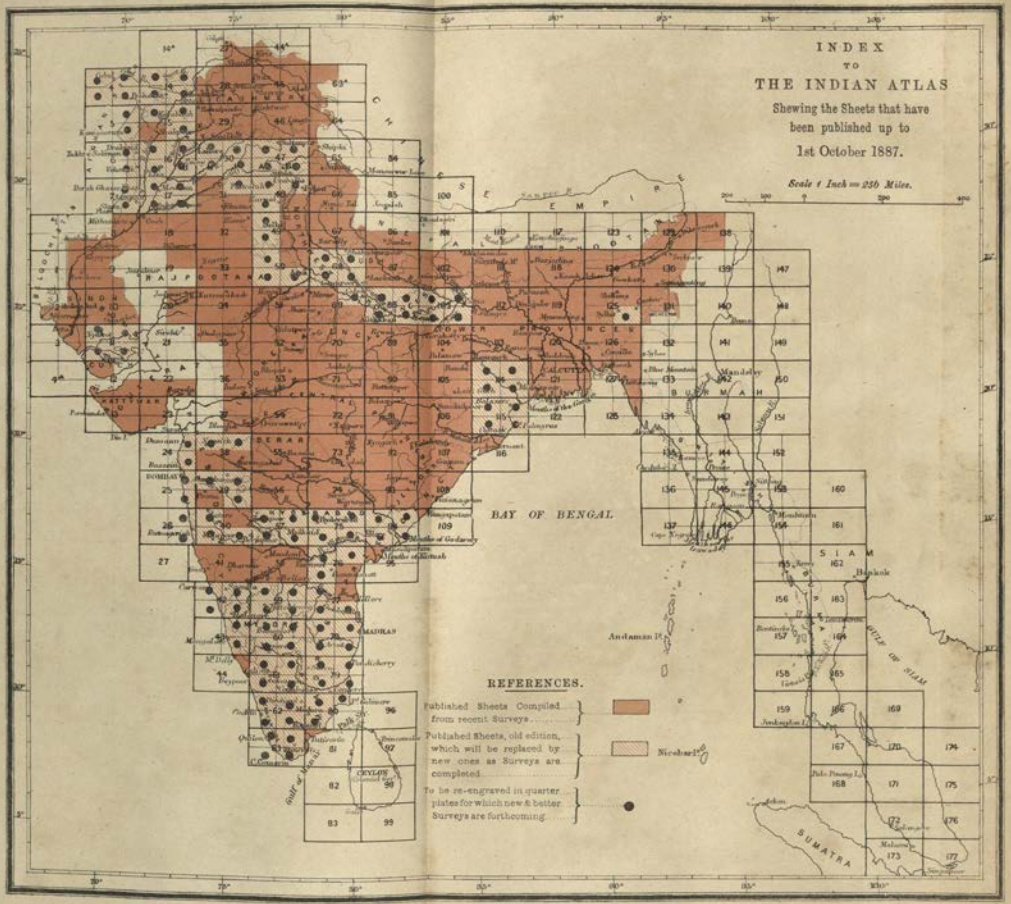
318. A map of Mysore on the scale of 1-inch=16 miles has been compiled and published in a preliminary form by photozincography. This map is now being engraved and is nearly complete in outline.

319. The experiments that were alluded to in last year's report as being carried on with a view to the production of the sheets of the Indian Atlas in some more rapid and economical way than by hand-engraving, have been only partially successful. The photozincographed sheet, though a good specimen of the process, will not for a moment bear comparison with an engraved map; the delicate cross-shading in the border especially having completely filled up and blotted. Another experiment by which it was hoped to reproduce brush-shading for the hills by the photo-electrotype process on copper was also a failure; the brush-shading is faulty and ugly, whilst the outline and names are not sharp and clear. A third method, however, has proved decidedly more successful; the original was drawn on paper very carefully in imitation of copper-plate work, about one-third larger than the true scale of the map; this was reduced by photography and then transferred to copper by the photo-electrotype process. The maps thus produced, though not equal to hand-engraved work, are good and the process is suitable for sheets in which geographical knowledge is at present limited, and which are likely to be superseded by more reliable materials. The saving in time, though considerable, is not quite so great as was at first anticipated, as the drawing of the original requires to be very carefully done by a first-rate draftsman.

320. The routine work of examining the fair maps sent in by the field parties of the Topographical Branch, before passing them on to the Photographic Office for reproduction, has been carried on; drawings for the preparation of the Atlas sheets have also been supplied to the Engraving Office.

SECTION II.—REVENUE.

321. The work in this section consists of examining and preparing for photozincography the fair maps drawn by the Revenue Survey parties, of correcting according to the latest orders the boundaries of districts, &c., on the office copies of all maps, and of supplying traverse data, plots of villages and tracings of unpublished maps to various Government officials. In the case of the Gorakhpur district, the cadastral sheets on the 16-inch scale are being reduced in this office and drawn fair on the 2-inch scale for reduction to one-half to lighten the office work of the field party.



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Survey of India Offices, Calcutta, January 1888.

SECTION III.—CADASTRAL.

322. This section has undergone no changes during the year. The usual work of examining the original sheets as they are received from the field parties, making them suitable for photographic reproduction, and comparing the details and the field numbers on the printed proofs with the originals has been carried on. The number of sheets so dealt with, as well as the number of sheets published is less than that of last year: this is owing to a decrease in the number of maps received from the field parties. As there was no likelihood of the supply increasing, the extra establishment consisting of nine temporary draftsmen was reduced to six; these men prepare tracings on transfer paper for zincography, of the maps of small villages or of those with very little detail on them. A map of the City of Benares in five sheets on a scale of 32 inches to the mile was examined and sent to the Photographic Office for publication.

323. Of original maps 110 volumes were arranged and bound up for record, and 24 volumes of printed sheets were also bound, indexed and examined for the Government of Burma. It is interesting to observe that the cadastral maps of District Benares are appreciated by the *zamindárs*; this is evidenced by the fact that the stock originally supplied to the Government Press at Allahabad has been exhausted, and, as the demand for these maps still continues, this office has been asked to issue a second supply of twelve copies of each village map. In the districts of Gorakhpur and Basti a depôt has been formed where cadastral maps of those districts may be purchased; for this purpose ten copies of all *pattidári* and five copies of all *zamindári* village maps are supplied.*

ENGRAVING OFFICE.

324. On the 22nd September, Mr. C. W. Coard, who has superintended this office from the time of its first commencement nearly eighteen years ago, retired on pension. He was selected in 1868, together with a small staff of European engravers, by General Sir Henry Thuillier, then Surveyor General, with a view to engrave and publish the sheets of the Atlas of India under his own superintendence instead of through the agency of the India Office. During these eighteen years many Europeans and Natives have been trained in the art of engraving, and their work will bear comparison with that done in Europe. Mr. Coard gave entire satisfaction throughout the whole of his service, and he has left the office in a high state of efficiency. Mr. G. G. Palmer, who also came out from England, but subsequent to Mr. C. W. Coard, has been appointed Superintendent on the retirement of the latter.

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General, in charge up to 6th June 1887.
Major A. W. Baird, R.E., Deputy Superintendent, 3rd grade, Officiating Assistant Surveyor General, in charge from 7th June 1887.
Mr. C. W. Coard, Superintendent, up to 22nd September 1887.
Mr. W. Donaldson, Engraver, on furlough.
„ G. G. Palmer, Engraver, Superintendent, from 23rd September 1887.
Mr. D. L. Mitchell, Engraver.
„ J. Fulford, „
„ T. B. Rodger, „
„ A. G. Palmer, „
„ S. M. Coard, „
„ A. W. N. James, „
„ A. R. Coard, „
„ A. D. M. Chamarette, „
„ E. C. Ollenbach, „
23 Native Engravers.
4 Apprentices and 1 Storekeeper.

Copper-plate printing section.

Mr. W. T. Collins, copper-plate printer.

325. The work completed during the year under report is much the same as that of last year; the amount of lettering is considerably below last year's outturn, in consequence of the absence on leave of Mr. Donaldson and of another writing engraver; the outlining is somewhat greater whilst the hill-etching is slightly less; two of the hill-etchers have been absent during the year, one having been employed on the heliogravure plates in the Photographic Office.

* The Officer in charge reports that Messrs. G. A. McGill and S. M. Smylie, who have been respectively in charge of Sections I and II, have done very good work; Mr. F. Adams, who superintends the examining of all maps belonging to Section I, has worked hard to try and prevent the examination of maps falling into arrears, the number of hands in his office having been considerably reduced in the last few years. Mr. Stotesbury has, besides superintending the cadastral section, rendered considerable assistance in checking the manuscripts of the catalogue, which is under preparation. Amongst the draftsmen, Mr. A. J. Musgrove and R. Sinclair have done especially good work. Assistant Surveyors S. O. Madras and E. J. Martin have given every satisfaction in their respective duties.

326. The number of sheets printed is less, there having been a smaller demand for miscellaneous plates, principally due to the fact that a press for the heliogravure plates has been set up in the Photographic Office, whereby this office is relieved of some of that class of work. This was desirable, as the printing section could not keep pace with the demands on it for departmental maps when so much of its time was occupied with these miscellaneous plates.

327. The six plates forming the map of India on the scale of 1 inch=32 miles have made good progress; there are still blanks which are due to want of finished survey work, but preliminary editions are published by transfers to stone, the blanks being filled in by the lithographer. It is difficult to say when the engraved plates will be fully complete, as this will depend on the progress of regular surveys throughout the whole of India. The two plates of Bengal, scale 1 inch =16 miles, are very nearly finished and the map will soon be published. The map of Rajputana and Central India on the same scale has been completed as far as the survey has been carried out; as the field party was ordered elsewhere, the portion left unsurveyed in the desert must necessarily remain blank for the present; the map will however be transferred to stone and completed from the best available sources and published as soon as possible. The 16-mile map of the Punjab has been outlined and good progress is being made in the writing. A similar map of Mysore has also been outlined. The other provincial maps have been corrected where necessary.

328. Small maps of Bengal and the North-Western Provinces on the scale of 1 inch =80 miles have been cut in outline; it is proposed to make electrotype duplicates of these in various stages, so as to have a series of maps commencing with one in pure outline and ending with one as highly finished as the scale will admit of. It is believed that these will be found very useful in illustrating different kinds of reports. Four new plates of the Atlas have been projected, forty-six repaired and added to, seven completed, whilst sixty-three plates are in hand in various stages of progress. Details of the work performed are given in the appendix, page civ.*

PHOTOGRAPHIC OFFICE.

329. The Photographic Office was in charge of Lieutenant-Colonel W. F. Badgley from the commencement of the year until the 28th October, when he was relieved, on his transfer to No. 19 Party (Madras), by Mr. T. Archdale Pope, whose appointment to the office was reported last year. Mr. Pope joined the office on the 14th October and officiated in charge from the 29th October until the 17th December when Lieutenant-Colonel J. Waterhouse returning from furlough, resumed charge of the office which he retained throughout the remainder of the year. Lieutenant-Colonel Waterhouse reports that Mr. Pope has been of considerable assistance to him in carrying on the work of the office during the year.

Personnel.

Lieutenant-Colonel J. Waterhouse, S.C., Assistant Surveyor General, in charge from the 17th December 1886.
Lieutenant-Colonel W. F. Badgley, S.C., Officiating Assistant Surveyor General, in charge from 1st to 28th October 1886.
Mr. T. A. Pope, Officiating Assistant Superintendent, 1st grade, assumed charge of his duties on the 14th October 1886 and was in charge from 29th October to 16th December 1886.

NEGATIVE SECTION.

Normal Establishment.

Mr. J. Mackenzie, Photographer, retired on 16th July 1887.
Mr. C. DeCruze, Assistant ditto.
„ Ismail Khan, „ ditto.
2 Negative retouchers.

Cadastral Establishment.

Mr. C. Marshall, Photographer, on furlough for 6 months from 3rd April 1887.
Mr. L. Lagnier, Photographer, on medical leave for 6 months from 13th June 1887.
Mr. T. Lloyd, and 3 other Assistant Photographers,
3 Negative retouchers.

COLLOTYPE SECTION.

Normal Establishment.

Mr. J. T. Meade, Printer, from 1st February 1887.
1 Printer.

ZINC PRINTING SECTION.

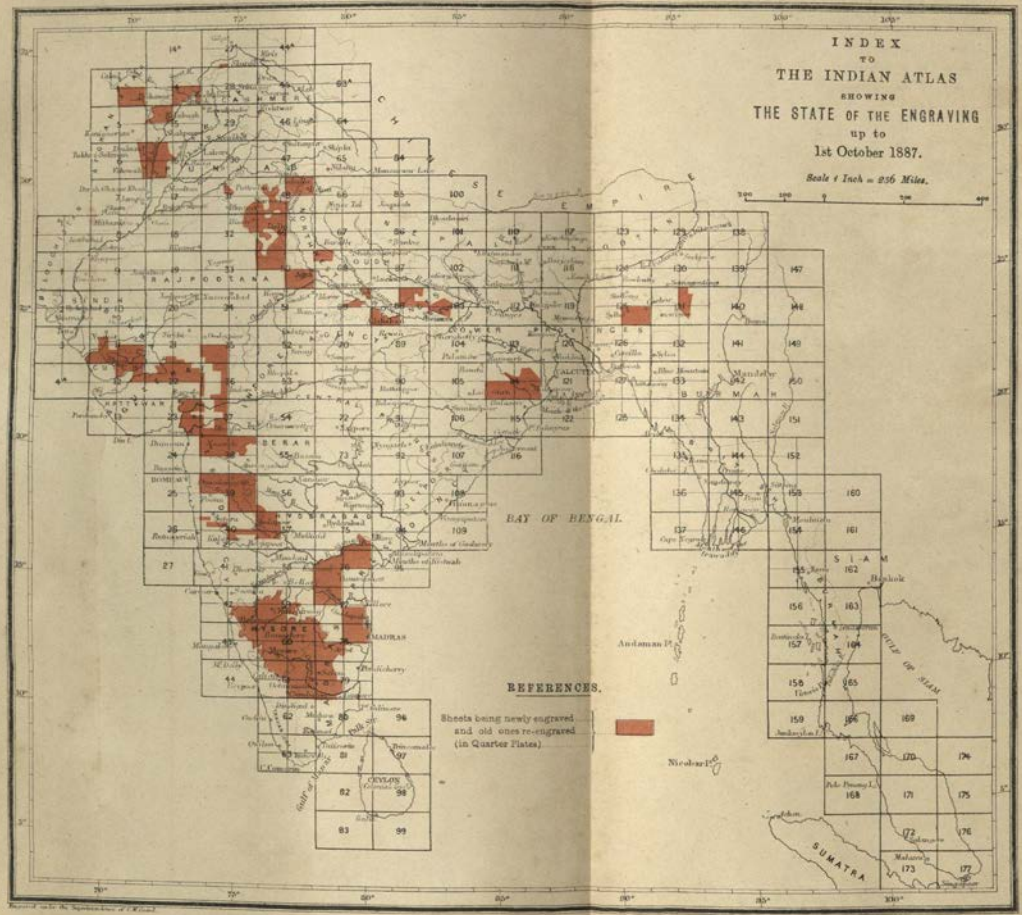
Normal Establishment.

Mr. B. Mackenzie, Zincographer
1 writer, 4 zinc-correctors.

Cadastral Establishment.

Mr. J. Watson, Zincographer.
„ E. A. LeFranc, ditto, on deputation to Litho. Office from 16th August 1887.
Mr. J. B. Mackenzie, Assistant Zincographer, 1 writer, 9 zinc-correctors.

* The European engravers have all been reported to have done their work well and ably; the same may be said of the natives with one exception. The apprentices have made good progress and are now capable of working in the simpler kinds of maps.



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Survey of India Offices, Calcutta, January 1888.

PHOTOGRAPHIC TRANSPER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Asst. ditto.

Cadastral Establishment.

Mr. R. George, Photographer.
2 Assistant Photographers.

SILVER PRINTING SECTION.

Normal Establishment.

Mr. G. G. Dempster, Photographer, working in the Negative Section (Normal Establishment)
1 Assistant Photographer.

HELIOGRAVURE SECTION.

Normal Establishment.

Mr. A. W. Turner, Photo-Engraver, in charge Collotype Section in addition.
Mr. L. H. Musgrove, Engraver, working in the Engraving Office.
Babu Joykristo Shaw, Engraver.
3 Copper-plate Printers, 4 pressmen.

GENERAL OFFICE ESTABLISHMENT.

Normal Establishment.

Mr. W. Moore, Store-keeper.
Babu Kanny Lall Sen, Clerk and Accountant.
Babu Gopal Chunder Mookerji, Clerk.
1 Clerk.

Cadastral Establishment.

Mr. H. Haward, Head Assistant in charge Collotype and Silver-Printing Sections, from 1st October 1886 to 11th August 1887, and in charge of Negative Section from 12th August to 30th September 1887, and 1 clerk.

APPRENTICES.

Mr. C. J. Meade, working in the Silver-Printing Section.
Mr. U. S. Ravenscroft, working in the Lithographic Office.
Mr. P. C. Michael, working in the Negative Section.
Mr. E. Savedra, working in the Silver-printing Section from from 1st June 1887.

330. Mr. J. Mackenzie, the Head Photographer, who had been in a bad state of health for some time past, retired on an invalid pension on the 16th July. He had been in charge of the Negative Section since the formation of the office in 1862, and by his skill, care and zealous attention to his duties, assisted largely in keeping up the high standard of work required. His place has been filled by Mr. H. Haward, the Head Assistant, who is thus placed in a position of greater responsibility and usefulness than he occupied in charge of the Photo-collotype and Silver Printing Sections, the work of which can now be carried on by two of the apprentices whom he has trained in that work.

331. The out-turn and value of work are shown in the abstract which follows: The number of original maps and drawings of all kinds received for reproduction was much under the average and the out-turn is consequently comparatively small. Only 4,803 original subjects were received (719 Departmental, 3,618 Cadastral and 466 Extra-Departmental) against 6,721 of last year (892 Departmental, 5,203 Cadastral and 626 Extra-Departmental). The falling off is principally in the Cadastral sheets, which is due to a smaller number of field parties having been employed on that class of survey, but the receipts of Departmental and Extra-Departmental maps and drawings were also below the average. The diminution in the receipt of Departmental maps is principally owing to the contraction of topographical surveys and the transfer of field parties to traverse surveys in which the reproduction of maps is not required. The number of negatives taken was 4,345, against 5,988 of last year. In the Zinc Printing Section the amount of ordinary departmental work was very much less than that of last year, the number of pulls being 72,920 from 495 plates, against 96,361 pulls from 612 plates, of last year; but on the other hand the Extra-Departmental work shows an increase, the number of pulls being 56,636 from 279 plates, against 55,440 pulls from 211 plates of last year. The out-turn of Cadastral sheets also shows a very large decrease, in consequence of the reduced number of sheets received; the number of sheets printed off being 3,744 with 116,081 pulls, against 5,282 sheets with 154,893 pulls of last year.

332. Less work than usual was also done in the Silver Printing Section, the total number of prints, silver and cyanotype, being 1,436 against 5,571 of last year. The exceptionally large out-turn of last year was, however, due to Exhibition work, and the reproduction of Colonel Durand's sketches taken while on the Afghan Boundary Commission.

333. In the Heliogravure and Collotype Sections the work done is more satisfactory both in quantity and quality, and both processes have now quite emerged from the experimental stage and taken their places as practical working methods. Thirty plates were prepared by the collotype process and 6,608 copies printed from them. Last year the numbers were 43 plates and 4,880 copies, but much of the work done was experimental or for purposes of instruction. This year also some of the work was experimental, but the greater part of it was undertaken in the current routine of the office for the reproduction of photographs of inscriptions, coins and architectural subjects for the illustration of the Archæological Survey Reports and the Journal of the Asiatic Society of Bengal, also of a photograph of a new species of *Ficus* for the Superintendent of the Royal Botanical Gardens.

334. The Heliogravure Section has been in steady work throughout the year and, by the adoption of methods which Colonel Waterhouse learnt at Vienna in 1886, considerable improvements have been made in the photo-etching process, details of which will be found in the appendix. A specimen of the work now produced, *viz.*, a medallion portrait of Her Majesty the Queen-Empress, is given in the frontispiece of this Report. There have been 22 plates reproduced in photo-electrotype, including Quarter Sheet No. 6 S.E. of the Indian Atlas which was reproduced from an original drawing in pen and ink, specially drawn for the purpose. A reduction in one sheet on the quarter inch scale of two standard sheets of the Andaman Islands, on the scale of 2 miles to an inch, was also done by this process, and it is intended to reduce the whole of the standard sheets of the Andaman and Nicobar Islands in this manner for publication instead of engraving them by hand. Twenty-two plates were prepared by the photo-etching process, including a reproduction of Atlas Sheet No. 14 S.W., from a brush-shaded original. This sheet, though rather coarse, owing to imperfections in the original drawing, shows the capabilities of the process in this direction, but there will always be a great difficulty in satisfactorily reproducing the combination of brush-shaded hills and outline on a map. The total number of plates produced by both processes was 45, against 30 of last year, and the number of copies printed was 292 (including 92 pigment prints). Further experiments have been carried on in the preparation of photo-typographic blocks in half-tones, with promising results, but the difficulty of printing these very delicate subjects in combination with type is likely to hinder the practical application of the process which would otherwise be a most valuable one.

335. There has been a considerable increase in the work of electrotyping the hand-engraved copper-plates, apart from photo-electrotype work. During the year 21 matrices and duplicates have been prepared, against 13 of the previous year. The plates duplicated include 3 quarter-sheets of the Atlas of India and 2 sheets of the 32-mile map of India, from which it is intended to prepare an outline map on the same scale for statistical purposes.

General Abstract.

Description of Work.	Sheets or Subjects.	Negatives.		Photo-zincographic Printing.					Silver and other Printing.		Heliogravure and Electrotyping.					Photo-collotype.		Value.		
		Negatives (Direct).	Negatives (Reversed and transparencies.)	Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo Blocks.	Electrotypes.	Plates.	Prints.	*R*	*a.*	*p.*
Departmental Maps and Plans	719	1,146	8	1,074	317	495	72,920	88,303	195	118	16	16	63	3	21	12	28	36,640	8	11
Cadastral Maps	3,618	2,502	...	2,524	3,744	3,744	1,16,081	1,08,832	...	...	...	...	...	...	...	...	...	54,501	7	9
Extra-Departmental Maps and Plans	466	697	16	701	261	279	56,636	73,478	1,113	10	6	7	229	...	...	18	6,580	22,080	5	0
Total	4,803	4,345	24	4,299	4,322	4,518	2,45,637	2,70,613	1,308	128	22	23	292	3	21	30	6,608	1,13,222	4	11

336. The departmental publications have been of the usual character and include nothing very specially worthy of notice; full details regarding them are given in the appendix. Considerable progress has been made with the series of District maps for administrative purposes, on the scale of 1 inch = 8 miles. Among the plans of Cities and Cantonments, those of Baroda City and Environs, in 16 sheets, on the scale of 200 feet to 1 inch; Dalhousie Sanatarium, on the scale of 6 inches = 1 mile; Dúngarpur Environs and Kherwára Cantonment, in 3 sheets, on the scale of 12 inches = 1 mile, and 9 sheets of Simla, on the scale of 24 inches = 1 mile, reproduced last year, have been printed off. A plan of Moulmein Cantonment, scale of 12 inches = 1 mile, and Rangoon Town District, in 20 sheets, scale 16 inches = 1 mile, have been reproduced and printed during the year.

Of Standard sheets, 283 have been printed off, including 10 of the Andaman Islands; 6 of Assam (District Cachar), 4 of Baluchistan, 5 of North-Western Provinces (Districts Ballia, Ghâzipur and Sarun), 40 of Bombay, 85 of Burma, 5 of Central India and Rajputana, 9 of Cutch, 15 of Gujarât, 43 of the Hooghly River Survey, 11 of Hyderabad, 1 of Káthiawár, 12 of the Konkan, 27 of Mysore and 11 of the Punjab. A preliminary map of Upper Burma was also published during the year.

337. A statement of the amount and value of work done for other departments is given in the appendix. Among the most important of the extra-departmental items may be mentioned maps of India showing Railways open to traffic, under construction and under survey; also India, showing Railways with stations, on the scale of 64 miles = 1 inch, both for the Director General of Railways. For the Quartermaster General, 8 more maps of the country round various cantonments have been reproduced, as well as several maps connected with the military operations in Upper Burma and a map of the Camp of Exercise at Lawrencepur, besides many miscellaneous maps and sketches. For the Port Commissioners, 5 sheets of the Hooghly River Survey and a chart of the Sandheads have been printed off, besides plans, &c., of the new Kidderpore Docks. For the Marine Survey, only one chart, White Point to Mergui, has been reproduced during the year. For the Meteorological Office a large number of Weather Charts and diagrams were photo-zincographed and a plate for the new Weather Chart of India was prepared by the photo-electrotype process, so that transfers can be made from it to stone whenever required. For the Government of the Punjab, 10 District maps on the scale of 1 inch = 4 miles were photo-zincographed. For the various branches of the Public Works Department, Imperial and Provincial, and for the Inspector General of Military Works, a large number of plans and drawings were reproduced as usual.

338. A commencement has been made in reproducing a series of archæological drawings, for the use of Art schools throughout the country and also for the illustration of the Journal of Indian Art. Six plates of some very beautiful drawings made for the Archæological Survey of Western India have been reproduced by heliogravure and transfers of all of them were sent to England to Mr. W. Griggs for publication in the Indian Art Journal. Unfortunately these transfers were not so successful as a preliminary one sent for trial, and it remains to be seen whether the plan will answer as well as was expected.

339. The book debit system upon which all business with other departments is transacted, has worked well throughout the year on the basis of the rates fixed in 1886. These rates were looked into shortly after Colonel Waterhouse's return from furlough, but there appeared no necessity for revising them during the current financial year. They will again be scrutinised and revised if necessary. Every effort is being made to reduce expenditure as far as possible.

340. Colonel Waterhouse reports that with the assistance of Mr. Pope a Code of Rules has been prepared for the guidance of the Lithographic and Photographic Offices which will be of great use as embodying the experience of many years. The stores accounts have been thoroughly revised and a new system of keeping the store ledgers adopted, which is working well.

341. Colonel Waterhouse has devoted a good deal of attention to the processes of orthochromatic photography for the better reproduction of coloured maps and drawings. Specimens of a very highly coloured water-colour drawing by Colonel Woodthorpe, reproduced on an orthochromatic as well as on an ordinary dry plate, are given with the extracts from Colonel Waterhouse's report in the appendix. The special advantage of this method is that the yellow and orange shades, which are usually reproduced by photography as black, come out light; while the blues, or shadows containing blue, which photograph white or much lighter than they should do, reproduce in their proper value as shadows. Full details of these and other processes which have been modified during the year will be found in the appendix.*

* Colonel Waterhouse continues to report very favourably of his European and native assistants and apprentices who have generally performed their duties to his entire satisfaction.

LITHOGRAPHIC OFFICE.

342. This office was in charge of Lieutenant-Colonel W. F. Badgley until the 28th October 1886; Mr. T. A. Pope then officiated in charge till the 16th December, when Lieutenant-Colonel J. Waterhouse, returning from furlough, resumed charge of the office and retained it for the remainder of the Survey year.

Personnel.

Lieutenant-Colonel W. F. Badgley, S.C., Officiating Deputy Superintendent, 2nd grade, Officiating Assistant Surveyor General, in charge from 1st to 28th October 1886.
Mr. T. A. Pope, Assistant Superintendent, 2nd grade, in charge from 29th October to 16th December 1886.
Lieutenant-Colonel J. Waterhouse, S.C., Officiating Deputy Superintendent, 2nd grade, Assistant Surveyor General, in charge from 17th December 1886 to 30th September 1887.
Mr. H. L. Lepage, Head Assistant.
Babu Ambica Churn Mookerji, Examiner.
Munshi Sobhan Buksh, and 24 others. } Draftsmen.
Mr. D. Deas, Head Litho. Printer.
„ B. Wilson, Assistant Litho. Printer, and 74 others.
Mr. E. DePyvah, Head Type Printer, and 25 others.
6 clerks and 12 others.
Mr. G. A. LeFranc, „ E. Dowling, } Apprentices.

343. The out-turn of work during the year, as shown in the following abstract, has been smaller than that of last year, which was an exceptional one; but on the whole it is up to the average, and the decrease is mainly due to the smaller number of departmental forms and printed copies of maps, &c., required.

The number of subjects printed off amounted to 647, of which 130 (including 45 forms) were departmental and 517 extra-departmental. This is 30 subjects less than last year, which reduction is more than accounted for by the difference in the number of forms printed in the two years. The total number of pulls was 263,136, or 161,736 less than last year. The number of complete copies was 244,777, or 112,100 copies less than last year.

344. In the Type Printing Section the amount of work in number of pulls was also below that of the previous year, owing to fewer professional and other forms having been demanded, but the actual number of items or pages set up was greater, *viz.*, 6,330 against 5,566 of the year before. The total number of pulls was 841,121, and of complete copies 424,886, against 928,114 pulls and 488,796 complete copies of last year.

General Abstract.

Description of Work.	Lithographic Printing.				Type-Printing.		Total Pulls.	Total Copies.	Value.	Remarks.
	Sheets or Subjects.	Stones.	Coloured Copies.	Uncoloured Copies.	Pages or items.	Pulls.				
Departmental.									R a. p.	
General Maps	10	20	1,170	125	...	...	4,610	1,295	1,286 15 0	
	3	3	...	...	...	...	...	...	897 6 0	Not yet printed.
Provincial Maps	1	1	...	285	...	...	285	285	41 0 0	
District Maps	7	7	...	1,150	...	...	1,150	1,150	1,013 10 0	
	7	7	...	...	...	...	...	...	1,146 6 0	Not yet printed.
Atlas Sheet	1	1	...	50	...	...	50	50	89 14 0	
Standard Sheets	16	16	...	3,100	...	...	3,100	3,100	5,467 10 6	
	6	6	...	...	...	...	...	...	2,448 8 0	Not yet printed.
Index Maps	4	7	1,500	250	...	...	3,250	1,750	210 4 0	
Miscellaneous	30	32	220	8,251	...	...	8,352	8,471	595 6 0	
Departmental Forms	45	46	...	86,710	...	...	98,478	86,710	8,275 0 6	
Total	130	146	2,890	99,921	...	...	119,275	102,811	21,472 0 0	
Work done for other Departments.	517	438	18,015	123,951	...	...	143,861	141,966	24,416 5 0	
Total of Drawing and Printing	647	584	20,905	223,872	...	...	263,136	244,777	45,888 5 0	
Work done in Type Printing Section.	...	...	...	...	6,330	841,121	...	424,886	14,359 3 0	
Total Value	...	...	...	...	...	...	...	...	60,247 8 0	

345. The principal items of departmental work printed are:—A map of the Rajputana Agency, in two sheets, on the scale of 1 inch = 16 miles, transferred from the copper-plates; nine standard sheets of the Oudh Revenue Survey, scale 1 inch = 1 mile, Districts Hardoi, Unao, Sitapur, Lucknow, Rae Bareli, Bahraich, Kheri and Bara Banki; and seven sheets of the Bengal Survey, District Jalpáiguri, on the same scale, were printed off.

Four sheets of the Oudh Revenue Survey, Districts Kheri, Sitapur, Bahraich, Gonda, Partabgarh and Sultanpur, and one sheet of District Mymensingh, on the scale of 1 inch = 1 mile, have been drawn during the year, and one sheet of District Jalpáiguri has been re-transferred.

The map of India showing Density of Population, on the scale of 80 miles = 1 inch, noticed in last year's Report, was completed and printed off. Also five sheets of the Canal map of India in six sheets, on the scale of 1 inch = 32 miles.

A commencement has been made of a new edition of the 32-mile map of India, which is very much needed for general purposes. Sheets 2, 4 and 6 are well advanced and the remainder will be proceeded with as soon as transfers can be obtained from the copper-plates.

The following District maps on the scale of 1 inch = 4 miles, made up from copper-plate transfers from the sheets of the Atlas of India, have been printed off, *viz.*:—(*Bengal*), Sonthal Pergunnahs, Khoolna, Jessore, 24-Pergunnahs and Nuddea; (*Central Provinces*) Hoshangabad; and the following have been completed on stone but not yet printed:—(*Assam*) Sibságar and Nowgong; (*Bengal*) Moorshedabad, Chumparun, and Burdwan; (*North-Western Provinces*) Ghazipur; (*Central Provinces*) Jubbulpore.

346. Among the principal items of extra-departmental work, the new Military and Railway map, in twelve sheets, on the scale of 1 inch = 32 miles, under preparation for the Quartermaster General's Department, has been steadily progressing during the year, three or four draughtsmen having being employed upon it most of the time. Five sheets, Nos. 1, 2, 3, 4 and 9, have been drawn and corrected this year. The four sheets, Nos. 5, 6, 11 and 12, of which the drawing was completed last year, have been examined and corrected. Sheets 3 and 4 will have to be re-done, newer material being now available. The last three sheets, Nos. 7, 8 and 10, are now in hand, and it is hoped that the whole map will be completed and printed off during the current Survey year.

A series of Crop maps of India, representing the cultivation of Rice, Jute, Sugar-cane, Tobacco, Indigo, Cotton, Wheat, Tea and Coffee, has been commenced for the Revenue and Agricultural Department, Government of India, and will be proceeded with as fast as possible. The Sugar-cane map is well advanced.

347. With the exception of the above, the extra-departmental work has been of the usual varied character; but the out-turn of printed work shows a falling off from last year, though the number of subjects reproduced is more, and the number of indenting officers has increased. During the year 517 subjects have been received from 55 indenting officers. The number of impressions printed off was 143,861 and the value of the work done was ₹24,416. Last year 487 subjects were received from 47 indenting officers, the number of impressions was 158,369 and the value ₹27,226.

348. The falling off in the demands for extra-departmental work is in some cases due to reduction in the number of printed copies of maps and plates required for the illustration of annual reports. It is possible also that the new rules for inter-departmental payment by book-debit for all work done for other departments may have tended to cause a reduction in the demands upon the office for printing work, without being deterrent to officers and departments requiring lithographic work done.

349. The book-debit system of charging for all extra-departmental work has been in force all the year. An examination was made early in the year of the rates fixed in 1886, but it was not found necessary to introduce any changes into them, and the financial result of the year's operations would go to show that they are about correct. Further experience is, however, necessary, and the rates will be examined again, if possible, before the commencement of the next financial year.

The tabular statements showing the details and cost of the work done will be found at page cxxxiii of the appendix. *

MAP RECORD AND ISSUE OFFICE.

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General, in charge up to 6th June 1887.
Major A. W. Baird, R.E., Deputy Superintendent, 3rd grade, on duty from 30th May, and Officiating Assistant Surveyor General, in charge from 7th June 1887.
Mr. A. E. Byrn, Head Assistant.
„ H. R. Vallis, Map-Curator, and 11 clerks.
Mr. B. M. Wilson, Assistant Surveyor, 2nd grade, attached.
Sub-Surveyor Modhusudon Dutt, ditto.

350. Colonel Beavan held charge of this Office until the 6th June 1887, when he proceeded on furlough and was succeeded by Major Baird, R.E., who held the post during the remainder of the Survey year.

351. During the period under report the number and value of maps issued were as follows:—

Maps issued.	Number.	Value.
		₹
General maps to Government officials	61,278	43,251
Ditto to India Office, London	3,253	4,065
Ditto to Agents	1,100	1,522
Ditto to private individuals on cash sale . .	6,816	8,043
Total .	72,447	56,881
Cadastral maps to Government officials	1,05,951	79,463
GRAND TOTAL .	1,78,398	1,36,344

352. Compared with the issues of the previous year, there has been a considerable decrease in the number of both general and cadastral maps issued during the year to Government officials: in the former because the demand for war maps and maps belonging to the Burma and North-Eastern and North-Western Frontier Series has diminished, and in the latter in consequence of there being only one cadastral party working in Burma and the number of maps received from the field parties was proportionally less.

The system of book debit, introduced last year for the inter-departmental adjustment of the value of maps published by this Department, has also doubtless operated in reducing the demand for maps, as officials are now required to provide in their Budget Estimates for the cost of all maps they may require for the administrative work of their departments.

The income derived from map sales amounted to ₹9,254, *viz.*, ₹8,043 realized from private individuals and ₹1,211 from sale Agents.

353. In the Revenue Section of the Office 558 applications were received for extracts from original records of the Revenue Surveys, from private individuals chiefly, and 2,251 copies of village plans were supplied at a cost of ₹5,144.

The following figures shew briefly the details of work:—

Applications received for maps	3,178
Letters issued in reply	2,946
Cash and credit map sale bills	1,021
Invoices and receipts issued for published maps . . .	1,883
Ditto ditto for cadastral maps . . .	240
Ditto ditto for extracts from original records .	178
Packets, parcels and local despatches	3,006
Ditto received in the office	740
Packages despatched by rail and steamer	430
Ditto received by ditto	210
Maps coloured for sale and issue	20,233
Ditto for other departments	1,725

* Lieutenant-Colonel Waterhouse reports that Messrs. Lepage and Deas continued to perform their duties very satisfactorily. Mr. DePyvah has also worked well, and the apprentices, Messrs. E. Dowling and G. A. LeFranc, have again made good progress. The native draftsmen and clerks have worked satisfactorily. Babu Ambica Churn Mookerji, Munshis Abdul Hamid, Abdul Mujid, Mahomed Yeasin, draftsmen, and Babus Russick Lal Shaw, Kedar Nath Ghose and Rajani Kanto Chatterji, clerks, deserve special mention.

354. The new catalogue of maps published by the Department is approaching completion. It is being prepared and issued in geographical sections; in addition to the parts of the sheets of the Atlas of India and of the Punjab Province, which were reported last year as having been published, those comprising the North-Western Provinces and Oudh have been published, whilst those of India and adjacent countries and of Bengal, Assam and Central India and Rajputana are in the press. The lists of the Central Provinces, Berar, Hyderabad, Madras Presidency and Bombay Presidency are in manuscript but require examination. Mr. Doran has been employed on this duty and a better out-turn would have been shown, but for the sudden demand for his services on field duty, on which he was employed for nearly six months. The catalogue of Burma Maps is held in abeyance till the Provincial Index is ready and the charts of India and of the North-Eastern and North-Western Frontier Series have yet to be compiled.

A list of the maps published during the year is given at page 92.*

MATHEMATICAL INSTRUMENT OFFICE.

355. During the period under report, *viz.*, from 1st April 1886 to 31st March 1887, this office has been incessantly and most actively employed on work of various descriptions, which shows no tendency to diminish: on the contrary, the figures go to show that the establishment as at present constituted, is barely strong enough to cope satisfactorily with the current duties. Even with the assistance of the extra grant of ₹300 per mensem for the payment of temporary workshop hands, which has been sanctioned as a tentative measure, the stock of repairable instruments on hand is steadily increasing.

Personnel.

Colonel D. Macdonald, B.S.C., Deputy Superintendent, 1st grade, Officiating Assistant Surveyor General in charge.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument-maker.
Mr. F. Marshall, Assistant Mathematical Instrument-maker.
64 Artificers on permanent establishment.
125 Artificers on an average on the temporary establishment.
3 Eurasian apprentices.

Store Branch.

Mr. C. O. Gray, Instrument Storekeeper, to 9th January 1887 and from 31st March 1887.
Mr. W. Campagnac, Officiating Instrument Storekeeper from 10th January 1887 to 30th March 1887.
Babu W. C. Chowdry, Material Storekeeper.

Office Establishment.

Mr. M. O'Brien, Head Clerk.
Mr. C. O. Gray, Officiating Head Clerk, from 10th January 1887 to 30th March 1887.
Mr. W. Campagnac, 2nd Clerk, to 9th January 1887 and from 31st March 1887.
Mr. M. C. Belletty, Officiating 2nd Clerk, from 10th January 1887 to 30th March 1887, and 6 other permanent clerks.

The annexation of Upper Burma, and the consequent extension of public works, such as surveys, roads, railways, &c., have perceptibly increased the demands on this office. The Military Department, too, are largely increasing their demands for survey and scientific instruments.

356. The new building intended for the future accommodation of this office has now happily been commenced; and there is a reasonable prospect of its being ready for occupation early in 1888. Thus one great desideratum, roomy workshops, and adequate space for storing the large stock of serviceable and repairable instruments, will have been attained.

357. Year by year efforts are being made to gradually add to the capabilities of the workshop, and to render the establishment more independent of outside assistance in performing its work. A few years ago, a circular dividing machine, by Troughton and Simms, was procured from Madras, where it had been lying useless for several years, and set to work. This enabled the workshop to re-graduate a large number of theodolites, which otherwise must have been either condemned as unserviceable, or sent to England at very considerable expense to be repaired. Till last year, all aneroid barometers had to be sent to the Meteorological Department to be tested, and compared with a standard barometer. By importing a machine from England this office is now in a position to do this work itself very satisfactorily. Before long, it is to be hoped that this office will be able to undertake gilding and chronometer repairing, and thus considerably reduce the cost of these operations.

358. During the year under review 36,969 instruments, valued at ₹1,91,183, have been added to the serviceable stock; and 37,391 serviceable instruments,

* The Officer in charge reports that Mr. B. M. Wilson, who has the charge of all Revenue maps, has discharged his duties satisfactorily, while Mr. H. R. Vallis, the Map Curator, and Mr. S. Hazrah, his assistant, have rendered especially good service.

valued at R1,83,519, have been issued on indent; showing a net increase of R7,664 in the value of the serviceable stock in hand at the close of the twelve months.

359. The following statement shows the sources from which the supplies of serviceable instruments were received:—

Source of receipt.	No.	Value.
		R
From England on indent	4,742	47,324
By purchase in local market	10,343	8,715
Manufactured in workshop	9,545	23,450
Returned to Store by public officers	2,580	19,461
From other manufacturing offices	4,722	668
From "repairable" stock after repair	4,998	89,485
From other sources	39	2,080
GRAND TOTAL	36,969	1,91,183

360. The repairable stock was increased by 5,192 instruments valued at R66,472, which is a slight falling off on last year, for which the number was 6,320 valued at R69,860. The total issues from the repairable stock amounted to 5,044 instruments valued at R60,793, showing that the value of repairable stock in hand had increased during the twelve months by R5,679. Of the above-mentioned issues 4,998 instruments valued at R60,012 were repaired in the workshop at a cost of R29,473 and transferred to serviceable stock at an enhanced value of R89,485.

361. Table A (page cxxxvii of the appendix) exhibits the debits against various departments on account of issues of instruments on indent, and for repairs executed for them by this office; and the credits to the same for instruments returned by them into store, either in a serviceable or repairable condition. The value of issues and repairs executed has increased from R1,81,175 in 1885-86 to R1,87,377 in 1886-87. The credits for instruments returned have diminished from R93,630 in 1885-86 to R87,253 in 1886-87. The cash sales have risen in value from R3,767 last year to R6,893. On the whole, the value of issues over receipts amounts to R1,07,017 as against R91,322 in 1885-86; so there will be a net increase of R15,695 in the credits to the Government of India under the head of "Revenue Receipts from Survey of India" over the preceding year.

362. In 1885-86, 16,151 instruments were purchased in the local market for R13,467. Under this heading there is a considerable decrease, only 10,343 instruments having been purchased for R8,715 in 1886-87. The details will be found in Table B (page cxxxviii of the appendix).

363. As regards instruments manufactured in the workshops, their number is smaller than in the previous year, but their aggregate value is greater. The figures are given below:—

	No.	Value.
		R
1885-86	13,453	21,453
1886-87	9,545	23,450

The class and value of these instruments are shown in Table C (page cxxxix of the appendix).

The number of principal instruments repaired in the workshops is 2,172, against 1,593 during the previous year. The total number of instruments repaired is 2,491. (*vide* Table D page cxli of the appendix).

364. The next statement (page cxlii of the appendix) is the "Profit and Loss account of the workshop." This exhibits a decided advance on the corresponding statement for 1885-86. The total value of work turned out is R67,405, being an increase of R6,493 in the value of the work done during the twelve months. The value of work done for public officers is less than in 1885-86; but work done for repairable stock and manufactures shows a marked increase. The workshop profit is R7,845, being more than double the amount for the previous year—R3,887.

365. As noted in the opening paragraph, the work of this office is very heavy and shows a marked tendency to increase. The increased number of instruments passing through the hands of this office causes a corresponding increase in the labours of the clerical staff, and also in the superintendence of the workshops. It is now many years since the clerical staff of this office was fixed at its present strength, and it will now be advisable to slightly increase the number of clerks. As regards the European superintendence of the workshop, it has been found that when short leave has been granted to either the Mathematical Instrument-maker or to his Assistant, that the duties of superintending such a large workshop are too onerous for one man. It must be borne in mind that native workmen joining this office require very careful training to begin with, and very close supervision, even after they have become efficient workmen, to prevent them scamping their work, or rapidly deteriorating. This supervision has to be carried on in a very trying climate. The ordinary appliances, too, which are available in most offices, for mitigating the rigour of the climate, cannot well be made available in a workshop.*

II.—TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

366. This office is divided into the following sections:—

(1) Correspondence, Accounts, and Stores.
(2) Computing.
(3) Type printing.
(4) Drawing and Compiling.
(5) Photozincography.
(6) Solar photography.
(7) Miscellaneous, Meteorology, &c.

The most important operations of the Trigonometrical Survey have been the execution of chains of triangles over the continent of India and extending beyond its limits; the determinations of azimuth from celestial observations at many of the stations of the triangulation; the observation of astronomical latitudes; the determination of differences of longitude by the aid of the electric telegraph; and the determination of sea-level at many places on the coasts of India and Burma, from which main lines of spirit-levelling are run over the country to form a basis for canal, railway and other operations. The principal work of this office is the final reduction and pub-

Personnel.

Colonel C. T. Haig, R.E., Deputy Surveyor General in charge Trigonometrical Branch.
Mr. W. H. Cole, M.A., Deputy Superintendent, 3rd grade, in charge of the Office.
Mr. J. Eccles, M.A., Assistant Superintendent, 1st grade.

(1) Correspondence, Accounts, and Stores.

Mr. C. H. McA'Fee, Surveyor, 3rd grade.
Mr. F. A. D'Rozario, Head Clerk.
Babu Mizaji Lall, and 4 other Native Writers.

(2) Computing.

Mr. C. Wood, Surveyor, 1st grade.
„ H. W. Peychers, Surveyor, 3rd grade.
Babu Ganga Pershad, Computer.
„ Cally Mohan Ghose, Computer.
Babu Cally Coomar Chatterji, Computer.
And 15 other Computers.

(3) Type Printing.

Mr. B. V. Hughes, Printer.
17 Compositors and Apprentices.

(4) Drawing and Compiling.

Mr. A. J. Wilson, Surveyor, 1st 1st grade.
Mr. G. W. E. Atkinson, Surveyor, 1st grade.
Mr. N. C. Gwynne, Surveyor, 3rd grade (joined 11th October 1886).

Drawing and Compiling —continued.

Mr. T. H. Rendell, Surveyor, 4th grade (joined 4th November 1886).
Mr. G. D. Cusson, Assistant Surveyor, 1st grade (joined 1st October 1886; transferred 1st September 1887).
Mr. H. Sindon and 6 other Draftsmen.
24 Assistant Draftsmen. Apprentice Draftsmen and Colourists.

(5) Photozincography.

Mr. C. G. Ollenbach, Zincographer.
„ R. W. Foster, Photographer.
1 Assistant Photographer, 2 Native Draftsmen, 1 Assistant Draftsman, and 1 Mapkeeper.

(6) Solar Photography.

Sergeant B. Rowland, R.E., Solar Photographer (services replaced at disposal of Military Department on 28th October 1886).
Mr. C. F. Guthrie, Assistant Solar Photographer (transferred from Photo-zinco. section on 1st October 1886).

* Colonel Macdonald reports very favourably of Mr. Bolton's abilities and efficient management of the workshops, and brings his services prominently to notice; Mr. Marshall's skill and industry are highly commended; Messrs. Gray and Compagnac are reported to be very painstaking and industrious; and the clerical establishment generally are commended for their efficiency.

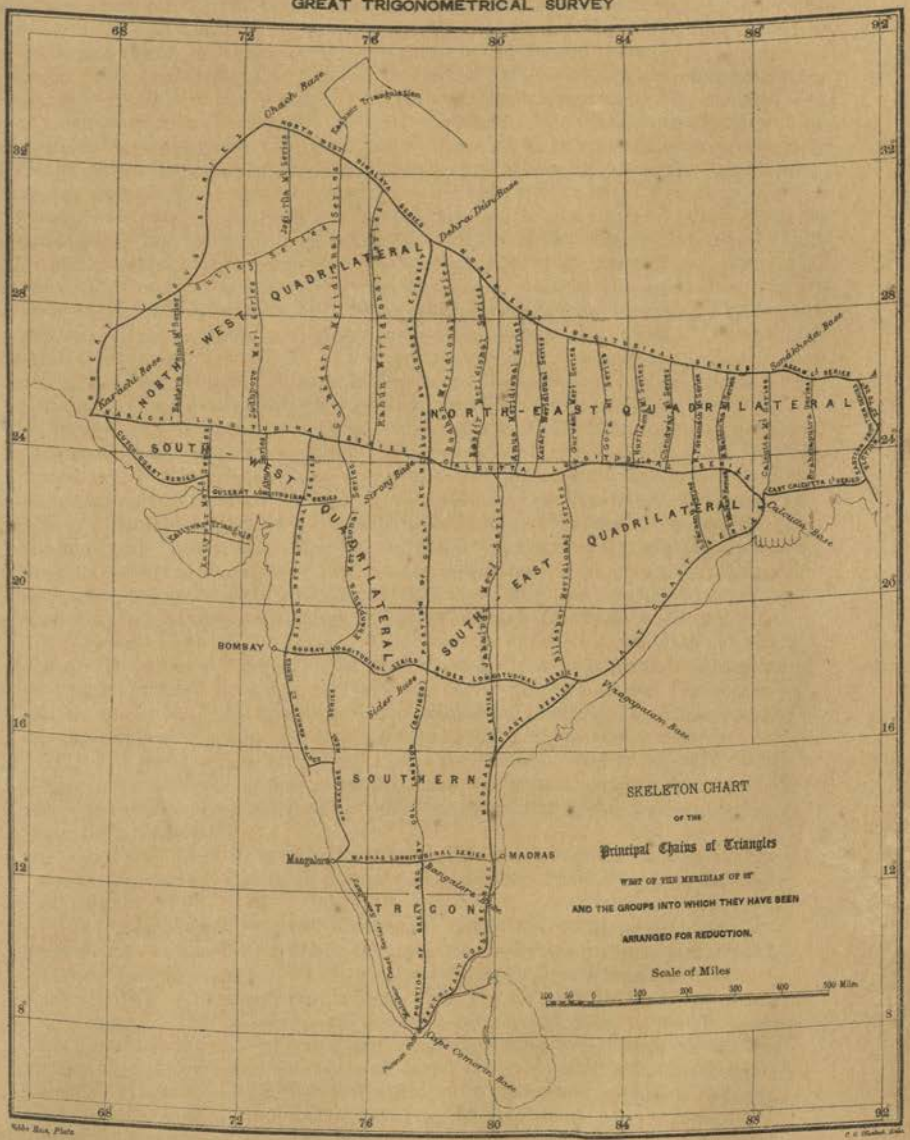
lication of the triangulation in all parts of India, including both the principal and secondary operations of the Great Trigonometrical Survey. Most of the publications being necessarily of a technical nature, and the office being located at a considerable distance from Calcutta, it has been found a great advantage that it possesses small printing, drawing, and photozincographic establishments, without which the accuracy of the technical details could not have been well maintained. The office has also a depôt of instruments (chiefly of the higher class) and stores attached to it, appertaining to the Great Trigonometrical Survey, of which it was the head-quarters. Among the instruments are, besides several large theodolites, the Colby compensation bars and microscopes for the measurement of base-lines.

367. (1) CORRESPONDENCE, ACCOUNTS, STORES SECTION.—In connection with this section it may be mentioned that this office usually equips officers and others proceeding beyond the frontier with efficient surveying instruments. The work in connection with the protection of survey stations has continued to be carried on as usual. During the year 886 stations have been repaired by district officers at a cost of ₹3,431. Of the 328 districts from which reports are due, those for 46 were not received.

368. (2) COMPUTING SECTION.—The chains of triangles, although executed with the best instruments available and with the utmost care and precision, were still, like all human undertakings, imperfect; and their imperfections appeared when a chain closed on a measured base-line or one chain met another, by small discrepancies showing themselves in the length of side and in the co-ordinates of the stations. The first great undertaking of the Computing Section was the rendering into one harmonious whole the principal triangulation of India between the meridians of 67° and 92° by the most approved mathematical processes, *i.e.*, by "the method of least squares." The triangulation was too extensive to render it possible to manipulate the whole at once, and moreover at the time the reduction was commenced, *i.e.*, about the year 1867, several chains still remained to be executed and two base-lines to be measured. The triangulation was accordingly divided up into five large sections (see diagram), designated the North-West, North-East, South-West, and South-East Quadrilaterals, and the Southern Trigon. During the past year the work of reduction and publication of the various operations have continued to proceed steadily under the able superintendence of Mr. Cole assisted by Mr. Eccles.

369. At the commencement of the year under report the whole of the reductions of the principal triangulation stood complete with the exception of a few details of the South-West Quadrilateral. These details are now disposed of, and the entire *principal* triangulation of India has been rendered consistent *inter se*, so that the correct length of every base-line is reproduced by the triangulation from any other base-line, and no circuit, however chosen, shews any closing error.

The results of the preceding calculations have been published as follows:—The North-West Quadrilateral in Volumes II, III, IV, and IV A of the Operations of the Survey; the South-East Quadrilateral in Volume VI, and the North-East Quadrilateral in Volumes VII and VIII. Of these Volume IVA was published during the year under review, and considerable progress has been made with the printing of the results of the remaining two large sections of the triangulation. In connection, however, with the principal triangulation, a great deal of subsidiary or *secondary* triangulation is always executed, chiefly with minor theodolites, for the purpose of fixing the positions of important towns, of conspicuous buildings, &c., to afford data for the topographical delineation of the country. This triangulation has also to be rendered consistent with the principal triangulation, and though much yet remains to be disposed of, a very large quantity has been finally reduced. All that appertains to the North-West and South-East Quadrilaterals is finished and the results have been published in Synoptical Volumes; one, *viz.*, Volume VIIA, containing the results of the Jodhpore and East Sind Meridional Series of the North-West Quadrilateral, having been completed and published during the year. Of the North-East Quadrilateral only the secondary triangulation of two series remains unpublished, *viz.*, that of the North-East Longitudinal Series and the Assam Longitudinal Series. The former has not yet been taken in hand owing to the field operations not being complete; the latter, which will include the work as far east as the extreme north-east frontier, is in hand and a good deal of time has been devoted to it during the year; it is hoped that the calcu-



Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún. January 1888.

lations will be finished during the next twelve months. The printing of the Synoptical Volume has been commenced. Up to the present time 23 Synoptical Volumes have been published containing the data of 33 series of triangles suitably arranged for the use of detail and other surveyors. The Southern Trigon embraces almost the whole of Colonel Lambton's net-work of triangulation, which is now treated as secondary, besides the secondary triangulation connected with each series. Much of Colonel Lambton's triangulation has been reduced to final terms during the year, and the whole of the secondary triangulation appertaining to one of the series, the South Konkan Meridional, is practically disposed of. The secondary triangulation of the South-West Quadrilateral has not yet been taken in hand.

370. The final reduction of the Astronomical latitudes was undertaken in 1879, and by the commencement of the year under report all the observations from Lambton's time to 1884-85 had been reduced and considerable progress had been made with the preparation of the results for the press. The progress since made has been the completion of the press copy, the writing of the explanatory chapters and the printing of more than 140 pages of the results and 30 pages of the chapters. Assistance has also been rendered to the officer in charge of the Astronomical Parties in the preliminary reduction of the observations of 1885-86. The electro-telegraphic longitude operations, which are carried out by Astronomical Parties Nos. 1 and 2, are reduced year by year by those parties aided by a pair of computers lent by this office during the recess season. The results when ready for the press are made over to this office to be printed. One volume of the results, *viz.*, Volume IX of the operations, &c., was published in 1883; a second volume, which will be number X, is nearly complete, and contains the operations up to season 1883-84 inclusive, and it is expected that it will be in the hands of the binder within the next two months. Subsequent operations are reserved for a third volume. The results of spirit-levelling operations, carried out by the Tidal Party, are sent to this office for publication. During the year, pamphlets Nos. 2 and 3 of Levels in the Bombay Presidency and Nizam's Dominions (revised), and No. 1 Madras Presidency, embracing the whole of the results from Bombay to Bider, Bangalore, Kárwár, Madras, and Beypore, have been completed and issued; and another pamphlet, containing the work executed in 1885-86 from Madras *viâ* Negapatam and Pámban to near Cape Comorin, has just passed through the press and will shortly be published.

The edition of the Auxiliary Tables to facilitate the calculations of the Survey Department, published in 1868, having been exhausted, a new edition was taken in hand in 1885; this has now been completed and copies are in course of issue. The book has been considerably enlarged and now contains over two hundred pages. It is anticipated that it will prove very useful.

It is necessary to state that all proofs are carefully read in the Computing Office, as it would be unsafe to entrust their comparison to men who are not thoroughly acquainted with the details of the calculations from which the results have been obtained.

371. (3) TYPE PRINTING SECTION.—The out-turn of this section has been steadily increasing for the last four years, and has more than doubled since 1883-84.

372. (4) DRAWING AND COMPILING SECTION.—This section has been principally occupied in assisting Major Gore in the compilation and drawing of trans-frontier maps, a work of considerable magnitude, required by the Government of India. The regular work of the office has accordingly been a good deal in abeyance. The following may, however, be particularised: a set of charts shewing the principal peaks of the Himalayan ranges was prepared for the Australian Geographical Society: two sheets of Levels in the Punjab and a new edition of one in the North-Western Provinces have been published. A map of M—H's route to illustrate a report on his explorations was compiled and published. A map of Mr. Carey's explorations was compiled from Mr. Dalgleish's survey of the route, and a tracing was supplied to Mr. Carey to illustrate a report to be read before the Royal Geographical Society, London. Other explorations were also plotted and a good deal of work of a minor character performed.

373. (5) PHOTOZINCOGRAPHIC SECTION.—The details of the work performed by this section are given in tabular form in the appendix. Considerable assistance has been rendered to the Forest Department and some to the

Foreign Office and the Quartermaster General's Department. The out-turn compares favourably with the expenditure.

374. (6) SOLAR PHOTOGRAPHY.—Photographs of the sun have been taken daily throughout the year for the Solar Physics Committee, South Kensington, except when the sun was invisible. In all sixty-three days were lost.

375. (7) METEOROLOGY.—The usual tabulated results of the meteorological observations are given in the appendix, where also will be found an account of the improvements introduced for the better supervision of some of the earth thermometers and the prevention of convection currents.

376. (8) EXPLORATIONS.—Besides the publication of the report on M—H's explorations, and the compilation of the account and map of explorer R. N. and his assistant's work in Bhutan, which are treated of in detail in Part II of this Report, the astronomical observations by Mr. Dalgleish taken in Eastern Turkestan and Mongolia, were examined and reduced, and his route survey (about 3,000 miles in length) was primarily adjusted.*

LIST OF MAPS AND CHARTS PUBLISHED DURING THE YEAR 1886-87.

TITLE OF MAP.	Scale.	Number of Sheets.	REMARKS.
	In. M.		
GENERAL MAPS.			
Skeleton Map of Afghanistan and Punjab Frontier	1=32	1	
Do. of the Baluchistan and Sind Frontier	1=32	1	
Do. of the Burma and Assam Frontier	1=32	1	
Contour map of India (reduced)	1=64	2	
Skeleton Map of Punjab and surrounding countries	1=32	1	(With additions to December 1886.)
ATLAS SHEETS.			
Quarter sheets Nos. 8S.W., 32N.E., and S.E., 38S.E., and S.W., 39S.W., 40N.E., 49S.E., 67S.W., 15S.W., 18S.E., 20S.E., 50 N. E.	1=4	13	
Sheets Nos. 28 and 50	1=4	2	
PROVINCIAL MAPS.			
Preliminary map of Upper Burma 1887 (1st and 2nd edition) reduced from the 4" reconnaissance sheets	1=16	1	
Rajputana Agency	1=16	2	
DIVISIONAL MAPS.			
The Presidency Division, comprising the districts of Moorshidabad, Nuddea, Jessore, Khoolna, 24-Purgunnahs and Sundarbans	1=8	1	
DISTRICT MAPS.			
District Bannu	1=4	1	
Do. Cachar with corrections to 1887	1=4	1	
Do. Hoshangabad	1=4	1	
Do. Jessore	1=4	1	
Do. Nuddea	1=4	1	
Do. Peshawar	1=4	1	
Do. Shajahanpur	1=2	2	
Do. Sonthal Pergunnahs	1=4	1	
STANDARD MAPS.			
Andaman Islands.			
Sheets Nos. 1, 5, 6, 7, 9 and 10	1=2	6	
Do. 6, 7 and 16	4=1	3	
Assam.			
Sheets Nos. 57, 68, 69, 70, 80 and 81 District Cachar	1=1	6	Preliminary Edition.
Bengal.			
Sheets Nos. 293, 294, 295, 296, 315, 316, 338 and 339 District Jalpaiguri	1=1	8	

* Mr. Cole reports favourably of his Assistants, making prominent mention of Messrs. Wood, Wilson, McA'Fee, Ollenbach and Hughes, who stand at the head of the various sections, and of Messrs. Atkinson and Peychers. He also mentions the intelligent interest taken in their work by Babus Ganga Pershad, Shivnath Saha, Shoshi Bhushan, and Mizaji Lal.

Title of Map.	Scale.	Number of Sheets.	Remarks.
STANDARD MAPS—*contd.*			
Bombay.	I. M.		
Sheets Nos. 81 1 S.E., 2 S.E., 3 S.E., 4 S.E., 133 1 S.E., 2 S.E., 3 S.E., 4 S.E., 134 1 N.E., 2 N.E., 3 N.E., 4 N.E., 1 S.E., 2 S.E., 3 S.E., 4 S.E., and 159 3 S.W., (Preliminary Edition), District Thana	4=1	17	
Sheets Nos. 133, 135, 136, 141, 161, 167, 169, 170, 171, 203, 238, 239, and 270, Districts Thana, Satara, Ratnagiri, Kolhapur, Kolaba, Surat, Nasik, Sholapur and South Maratha Agency	1=1	13	
Burma (N. E. Trans-Frontier Series).			
Sheets Nos. 15 N. E., 15 S. E., 23 N. W. and 23 S. W.	1=4	4	Compiled from Reconnaissances.
Burma (S. E. Trans-Frontier Series).			
Sheets Nos. 1 N. E., 1 S. E., 2 N. E., 2 S. E., 3 N. E., 4 N.W., 4 S. W., 5 N. W., 5 S. W. and 6 N. W.	1=4	10	Compiled from Reconnaissances.
Burma (Lower).			
Sheets Nos. 77 4 N.E., 92 3 S.E., 4 S.E., 93 1 N.E., 2 N.E., 3 N.E., 4 N.E., 1 S.E., 2 S.E., 3 S.E., 4 S.E., 94 2 N.E., 4 N.E., 2 S.E., 110 1 N.W., 3 N.W., and 1 S.W., Districts Tharrawaddy, Prome, Tounghoo and Shwegyin	4=1	17	
Sheets Nos. 74, 77, 92, 93, 130, 180, 182, 184, 185 Districts Prome, Henzada, Tharrawaddy, Bassein	1=1	9	
Sheets Nos. 94N.E., N.W., S.E., S.W., 106N.E., N.W., S.E., S.W., 115N.E., N.W., S.E., S.W., 123S.E., S.W., 124S.E., S.W., N.E., N.W., Districts Tharrawaddy, Hanthawaddy, Pegu, Shwegyin.	2=1	18	
Central India and Rajputana.			
Sheets Nos. 219, 252, 400 (2nd edition) and 401, Natives States of Gwalior and Bickaneer, and Districts Hissar and Jhansi	1=1	4	
Cutch.			
Sheets Nos. 54, 55, 56, and 69, Parts of Cutch, Morvi, Thar, Parkar, N. Gujarat, Pranthal, and Great Ran	1=1	4	
Gujarat.			
Sheets Nos. 41 1 N.E., 3 N.E., 3 N.W., 4 N.W., 1 S.W., 2 S.W., 3 S.W., 4 S.W., 42 3 N.W., 158 2 N.E., 4 N.E., 2 S.E., and 190 (Section 9), Districts Nassik, Panch Mahals, and Rewa Kantha States.	4=1	13	
Sheets Nos. 133 and 159, District Surat	2=1	2	
Hyderabad.			
Sheets Nos. 201, 210, 211, 218, 219, 221, 223, 224, 225	1=1	9	
Sheets Nos. (202, 203, 212, 213) (204, 205, 214, 215, and 222) (208, 209, 216 and 217), Kamamet Circar	1=2	3	
Kathiawar.			
Sheet No. 79 (2nd edition). Parts of Halar, Kathiawar and Gohelvad	1=1	1	
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Sheets Nos. 44 and 45 (2nd edition). District Chumparun .	1=1	2	
Northern Trans-Frontier Series.			
Sheets Nos. 20 and 21, part of Tibet	1=8	2	
North-Eastern Trans-Frontier Series.			
Sheets Nos. 5 and 6, parts of Tibet, Sikkim and Bhutan .	1=8	2	
Sheets Nos. 7 $\frac{N.W.}{1}$ and part of 6 $\frac{S.W.}{3}$, 7 $\frac{N.W.}{3}$ Sikkim .	1=2	2	
North-West Provinces.			
Sheets Nos. 56 B, 194, 208 (Preliminary Edition), 209 and 217 (Preliminary Edition), Districts Ballia, Sarun, Ghazipur, Jalaun and parts of Gwalior and Datia Native States.	1=1	5	
Oudh.			
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Punjab.			
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City, Cantonment, and Environs of Bangalore . . .	12=1	13	
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City, Cantonment and Environs of Bhuj	12=1	7	
City and Environs of Dungarpur	6=1	1	
Government Cattle Farm, Karnal	16=1	4	
Cantonment of Kherwara	12=1	2	
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HOOGHLY RIVER SURVEY.			
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APPENDIX.

EXTRACTS

FROM

REPORTS BY EXECUTIVE OFFICERS.

Extract from the Narrative Report of MR. E. C. RYALL, *in charge No. 24 Party,—Season 1886-87.*

COAST TRIANGULATION.

The entire length of the coast line triangulated was 170 miles northwards from Madras, and nine beacons were fixed and erected on it, exclusive of Madras, Pulicat, and Armugham Light-houses. Including these they run in straight line intervals as follows:—

	Miles.
Madras Light-house	...
Ennur (Ennore) Beacon	10
Pulicat Light-house	13
Pulanjerikuppam Beacon	15
Palm-tree	14
Palm-tree	1½
Armugham Light-house	9
Kottapatam Beacon	16½
Kistnapatam Beacon	15½
Pennér Beacon	19½
Wüturpalliepalem Beacon	17½
Ramapatnam Beacon	15½

The coast from Madras up to Masulipatam to an average distance of twelve miles inland is extremely flat, and consequently very much covered with lakes and swamps. In the neighbourhood of the coast itself there are a series of creeks and backwaters, which are connected with each other by canals. These creeks and backwaters, so connected form the well known Buckingham Canal. The largest lake, or more properly speaking swamp lake, is that of Pulicat—an expanse of water 35 miles in length north and south, with an average width of 6 miles, the greatest width being 11 miles. It receives the drainage of a comparatively small area, and is chiefly fed by the high tides of the sea, the inlet being to the south of the small town of Coromandel.

Further inland for about 10 miles or up to 22 miles from the coast the ground is broken up into scattered hillocks seldom rising over 150 feet, consisting of rocks of the metamorphic series, chiefly quartz resting on granite. The granite seldom shows itself except at elevations over 400 feet. Beds of laterite occur all along the coast, they are in general deeply covered over with sand and alluvial deposits.

The chief rivers are the Kalangi draining into the Pulicat lake, the Swarnamukhi, the Vuppateru, the Pennér (Paner), the Mannér, the Pálur, the Museru, the Gundlakamma, and the Kistna; the largest of these in order of size are the Kistna, the Pálur and the Pennér. The Kistna alone brings down with it rich alluvial soil. By the remaining rivers, which drain into the Nellore district, sand and gravel chiefly are brought down, rendering the soil very poor. The cocoanut, the palmyra and the casuarina (of all of which there are numerous and dense plantations) are the chief sources of profit to the inhabitants. The casuarina is comparatively speaking of modern introduction. All along the coast line extensive patches of these plantations are to be seen, and they were no mean obstacles to the triangulation. The casuarina is said to arrive at full maturity in ten years; the trees seldom reach 40 inches in girth and are on an average only about 24 inches, but they frequently attain to a height of 70 feet and sometimes more.

There are no ports between Madras and Masulipatam. Not even native vessels of small draught can enter into any of the mouths of the abovementioned rivers. The Buckingham canal is the only highway for traffic of a heavy nature, and this has to be continually dredged to allow the passage of vessels of 3½ feet draught.

The belt of country, almost 20 miles in width, is devoid of masonry structures except in a few places; mud-houses, sometimes tiled, and huts, constitute the chief abodes of the people.

Extract from the Narrative Report of MR. A. M. LAWSON, *in charge No. 10 Party, —Season 1886-87.*

SOUTH MARATHA COUNTRY.

Sheet 243 was mostly surveyed last season, but has been finished and drawn this season. It comprises a portion of the Sávantvádi State, the villages of the Chief of Hira, and the western part of the Belgaum *taluka*. The Sahyádri hills cross the sheet, with a very irregular outline, from north to south, and from the western face of the main range spurs break away, with deep densely wooded gorges between. To the east of the Sahyádris, the hills are in detached ranges, generally stretching north-east, and having peaks with bold and varied outline, some of which rise to a height of 3,400 feet, and some are surmounted with strong natural forts famous in Maratha history.

Sheet 243. General description.

Párgad (2,419 feet), a fort on the Belgaum-Sávantvádi frontier, is built on a peaked hill scarped on all sides, and surrounded by deep thickly wooded ravines. It was one of the forts held by Shivaji at the time of his death, and is now occupied as a police outpost.

Forts.

Kálánindhigad (3,333 feet), a ruined fort on the Ram Ghat road, is situated on the highest point of one of the Sahyádri spurs.

Gandarvagad (3,226 feet). The site of this fort is on a range of hills 20 miles west of Belgaum. It was built in 1724 by Nág Sávant, the second son of the great Phond Sávant, and has been the scene of many captures and recaptures. The fort defences have almost disappeared and the site is now a hamlet occupied by peaceful cultivators.

Mahipálgad (3,269 feet). This fort stands on the north-east corner of a considerable plateau 10 miles west of Belgaum. The walls with round towers on the angles and sides are still standing, and inside there is a large well and several inhabited houses. The fort belonged to Chintámanrao, the Sángli Chief. At his death in 1680 Shivaji is said to have held Mahipálgad. There are some rock-cut caves and temples on the eastern face of the plateau.

Two metalled roads cross the sheet from east to west. The Ram Ghat road was the old military route between Belgaum and Vengurla, but while the approaches to the Rám pass above and below are well kept roads, the pass is now impassable for loaded carts. There is still, however, a considerable amount of bullock traffic, salt and saltfish being taken from the coast and grain from inland. The travellers' bungalows on the route are kept in repair. The bungalow at Ram Ghat (in Sávantvádi limits) is beautifully situated on the edge of a densely wooded gorge overlooking Goa territory, with the sea in the distance; and as large game is abundant in the neighbourhood, it is a favourite resort for those fond of sport.

Roads.

The new road from Belgaum to Vengurla by way of the Amboli pass was opened in 1871, and is a first-class road metalled and bridged throughout. During the fair season, when the port of Vengurla is open, the cart traffic is immense. There are travellers' bungalows along the route, and at Amboli on the crest of the Ghats the Raja of Sávantvádi has built a summer residence. There are several other houses built and some under construction, and it is hoped that from the rare wildness and beauty of the scenery around Amboli and the comparatively cool climate it will become a favourite sanatarium for Belgaum as well as for Sávantvádi.

In addition to the above, two other unmetalled roads form lines of communication between the Amboli pass road and the Rám pass road. The first from Amboli follows the crest of the Sahyádri hills passing through Chowkoli and meeting the Rám pass road near

the Rám pass bungalow. The other leaves the Amboli road at Sirgaon and passing Chandgad and Hira joins the Rám pass road near Patna.

Rivers.

The rivers draining to the west are, from the nature of the country, mere mountain torrents, the only exception being the Tilári, rising some distance inland near the village of Tudiya at an elevation of 2,600 feet; it flows west draining the Dhamna and Máhálungi hills on either side. The force of its current has cut back through the face of the Ghats forming what is known as the Tilári Gorge. At Kedra where it enters Sávantvádi the elevation of its bed is 478 feet. Crossing the old military road near Ghotagevadi it leaves the sheet. During the rainy season the Tilári becomes a mighty torrent difficult and dangerous to cross, and so sudden are its freshets that no year passes without loss of life from drowning. The other rivers draining north-east from the Sahyádri hills leave the sheet before they become of much importance. The Ghatprabha rising near Chowkoli flows north-east for about 40 miles, leaving the sheet at Uchalli. The Támraparni has its source in the hills north of the Rám pass and flowing north-east between the Gandharvagad and Mahipálgad hills falls into the Ghatprabha at Yartenhati, 6 miles north of the limits of the sheet.

Villages.

There are no villages of much importance in Sheet 243, but Chandgad may be mentioned, it being the head-quarters of the subdivision of that name; besides revenue and police offices, it has a post office and school.

Hira, the residence of the Chief of that name, has a weekly market.

Sheets 305 and 306 comprise parts of the Belgaum, Dhárwár and Kaládgi collectorates and part of the Rámdurg and Torgal *jagirs*.

Sheets 305 and 306. General description.

The Manoli hills—a flat-topped range—separated by the Malprabha river from the Mudkavi hills, cross Sheet 305 from west to east as far as Soriban, where a spur turns north. The southern face of the hills is steep and more or less scarped, the flat tops being overgrown with thorny jungle and strewed with loose angular stones. The hills have generally a gentle slope on the northern face.

There are other detached groups and isolated hills, notably the Yeláma group, which extends into Sheet 306. The group takes its name from the shrine of the goddess Yeláma, which is held in great veneration throughout the Bombay Karnátak, and is visited yearly by about one hundred thousand pilgrims. The shrine is built in the bed of the Sarasvati, a small stream, which runs north from the hills into the Malprabha. The priests who officiate at the temple are Lingáyats, and live on the hill. One quarter-anna is levied from every pilgrim for the use of the temple, but in addition to the fee almost every pilgrim gives clothes, cash and ornaments. Of these the money gifts, which are estimated to bring in about ₹10,000 yearly, belong to the priests. The clothes and ornaments are presented to the goddess and become temple property.

Parasgad fort stands on the south-west edge of the Yeláma plateau. The walls are built of stone, but are in ruins and most of the bastions are out of repair. There is a hollow in the western face of the rock, with a spring which is esteemed sacred by the people, and an underground cave. Parasgad is said to have been built by Shivaji in 1674.

Rivers.

The Malprabha enters the south-west corner of Sheet 305, at the village of Yengi, and flowing east about 10 miles, turns abruptly to the north, passing the village of Ganial, where it rushes violently through a gorge in the Manoli hills. The gorge, which is about 300 feet deep, includes an upper or northern half, not more than 50 yards wide, and a lower half which is broader, and with lower banks. During floods, the water rises 30 to 40 feet in the gorge, and rushes with mighty force, forming pot-holes of great size and depth, which at every new-moon, in the fair season when the water is low, are visited by numbers of Hindu devotees. The gorge is known by the name of the Naul Tirth or Peacock's Pool. The local story is that a peacock hard pressed by pursuers, and too weary to fly over the chain of hills, rested on a large rock, and called piteously. The river heard its cry, clove the hills, and the peacock escaped. Emerging from the gorge, the Malprabha passes Manoli, then north-east to Torgal where turning east it passes Rámdurg, and flowing through a gap between the Manoli and Mudkavi hills, continues its course south-east until it leaves the sheet. The only other rivers of importance are the Bennihalla and Tuparihala. The Bennihalla enters Sheet 306 from the south and flowing north for 3 miles, then turns north-east passing Navalgund, continuing this course until it leaves the sheet. The Tuparihala rising in the hills near Kittur enters Sheet 306 on the west and flowing east by Betgeri falls into the Bennihalla near Navalgund.

Roads.

Sheets 305 and 306 are well provided with roads. The principal lines of communication are the Belgaum-Kaládgi road which crosses the north-west corner of Sheet 305 and the Gokák-Nargund road which meets the Hubli-Bijápur road at Nargund. Another road runs south from Nargund by Navalgund, meeting the Hubli-Gadag road at Annigiri. There are several other sections of road some of which are under construction.

The chief towns and places of interest falling within Sheets 305 and 306 are—

The fortified town of Torgal, beautifully situated on the left bank of the Malprabha, where the river flows between the Torgal and Manoli hills. The fortifications are said to have been built by Adil Shah, one of the Bijápur Kings. The Chief of Torgal resides in a

small fort inside the village. Here is a police station, a post office and a school. Torgal is connected by a well made road with Ramdurg and Soriban on the east and with Katkol on the west.

Rámdurg, a large town on the left bank of the Malprabha, has five schools, a courthouse, police station and post office. There is also a temple of Venkatesh where an annual fair is held in the month of April. The Chief of Rámdurg resides in a small fort to the west of the town.

Manoli, on the left bank of the Malprabha, has a post office and weekly market. A ruined fort stands on a peninsula round which the river winds. It was here that Colonel Wellesley defeated the freebooter Dhundia Vagh in July 1800, driving 5,000 of his men into the Malprabha where they were drowned.

Saundatti, the head-quarters of Parasgad subdivision, lies 6 miles south of Manoli. Besides revenue and police offices, it has a dispensary, sub-judge's court, post office, a collector's bungalow, two schools and a ruined fort, on a small isolated hillock to the west of the town.

Nargund, on the Hubli-Bijápur road, is the head-quarters of the Nargund petty division. The town lies at the foot of a steep hill on which stands the ruined fort of Nargund. In 1858 Bába Sáheb, the Brahman Chief of Nargund, raised the standard of revolt against the British Government, and on the 29th of May surprised the Political Agent, Mr. Manson, at night, when asleep in the village of Soriban, killed him, cut off his head, and fastened it over the gate of Nargund fort. The Chief was subsequently executed at Belgaum and his State forfeited to the British Government.

Navalgund is a municipal town and the head-quarters of the subdivision of that name. There are revenue and police offices, dispensary, post office and schools.

Extract from the Narrative Report of COLONEL H. C. B. TANNER, *in charge No. 18 Party, —Season 1886-87.*

HIMALAYAS, PUNJAB.

The 4-inch work was contoured by means of the clinometer at 500 feet intervals in the low tracts and 1,000 feet in the higher mountains. The field sections were shaded in with 33·3 feet vertical intervals between the lines, but this was found to give results too close and confused, and the fair maps have been drawn with 50 feet intervals. This gives a clear topographical map on which only a few small features less than 50 feet high are omitted.

We show on the sheets the following items :—

(1) *Bhoja** or *kothi* boundaries without the boundary marks but with tri-junctions of included *mauzas* and *phatis.*
(2) Forest Department blocks with forest cairns.
(3) The approximate limits of cultivation and of forest lands.
(4) All the chief lines of communication.
(5) All villages and hamlets with their names.

The demarcation of *kothis, bhojas* and forest blocks as a rule are good, but owing to the absence of fairly correct *shajra*† maps or of the usual *mujmilli,* which is always furnished by the Settlement Department for the guidance of surveyors, our men had great difficulty in shewing the correct boundaries.

This was more specially the case in Seorá̃j, where there were either no forest maps at all, or else those that were used by the surveyors were found to be of such bad quality that practically they were of no use whatever, and our men had to trust solely to the word of the Forest menials who sometimes omitted to point out all the boundary pillars.

The triangulation has been carried out in the usual manner, and it is only necessary to note here that the localities in which the operations were conducted are disconnected from each other, and thus a loss of power has ensued. Most of the stations of the old North-West Himalaya triangulation were found.

The bar subtense method has again been followed. In Morní the revenue survey village by village polygon system was wrongly adopted, and loss of time and labour has been the result. Where a system of triangulation extends over a country to be traversed the main traverses should run in a nearly direct line between suitable trigonometrical points, and sub-traverses should then be based on the stations of the main traverses. This system gives simple results which can readily be computed. It has been followed in Shahpur Kandi and Pálampur, and the Morní work which was first computed on the polygon system ignoring triangulation stations, has been recomputed in the proper way.

In Morní all the *bhoja* and *mauza*‡ tri-junctions have been fixed by traverse. The country is highly mountainous and it is thought that the Settlement Department will

* A *Kothi,* or, in the Morní State, a *Bhoja,* is a collection of several village lands under a single *Mukia* or headman who is responsible to Government for the revenue of the *kothi ;* it is therefore somewhat similar to an *ilaka* in other parts of India.

† A *Shajra* is a village map on which is recorded every individual holding of land in the village.

‡ A *Mauza* includes an area within convenient and generally natural limits and all the habitations therein.

be unable, except to a limited extent, to base their settlement maps upon these fixed points. In consultation with Colonel Wace, Financial Commissioner, it has been arranged that in future, only such open ground as seems capable of being accurately mapped on the 40-*kadam* scale (27·68 inches = 1 mile), shall be traversed by the Himalaya Party. This will curtail the traverse operations to a very appreciable extent, for the surveyors will in future omit all traverse work in regions which are mountainous and will fix tri-junctions only in those tracts where we may reasonably expect that settlement maps may be easily based upon them.

The 4-inch = 1 mile survey will be taken up in Shahpur Kandi and Pálampur, and later in the field season the Seoráj survey will be continued. Sheets Nos. 290 and 313 N. W. and S. W. will also be completed up to margin on the 2-inch scale. These sheets contain partly British and partly Native States land. It has been arranged with the Punjab authorities that the 2-inch survey shall embrace a topographical delineation of the general run of village boundaries. Limits of cultivation are not required, but masses of forest will be shewn. Traversing will be continued in Pálampur and in the open parts of Kulu. Besides this, the fixing of Himalayan peaks from the tower stations in Pilibhit and Sháhjahánpur will be carried out by two trained Sub-Surveyors.

Three soldier surveyors joined the party from Roorkee at the commencement of the field season. They have become efficient plane-tablers and have executed route surveys in the Himalayas. Two of the men have done remarkably well in route surveying and the third fairly. They have all learnt the use of the theodolite and aneroid. They are now about to commence a plane-table survey of a tract on the ½-inch scale, basing their map on two or at most three plotted points, after which they will be instructed in the use of the sextant and artificial horizon for latitude observations. The subject of the instruction of these men is now under reference and a final scheme may soon be looked for. It is proposed that the whole course, including half a year at Roorkee, shall not exceed two years' duration.

The Morni traverses have been plotted on 161 sheets on the scale of 40-*kadams* (27·68-inch=1 mile) to an inch by pupils attached to the office of the Himalaya Party by the Director of Settlements. They have also made tracings of the Morni sheets for the Settlement Officer, Umballa, to serve as an index to his work now about to commence in Morni or Kotáha.

Extract from the Narrative Report of COLONEL W. F. BADGLEY, *in charge No. 19 Party,—Season 1886-87.*

MADURA DISTRICT, MADRAS.

The area plane-tabled consists of a block of hills from 4,000 to above 8,000 feet high, including the south-west corner of the Palnis and parts of Madura and Travancore. It is for the most part bare but exceedingly rugged, some of the precipices being tremendous—such that a body falling with a slight impetus, would touch nothing for a quarter of a mile. The difficulty of surveying this country was therefore not so much in sketching what was travelled over as in getting from place to place; and this was increased by the laziness of the coolies who twice failed to come into camp, leaving me on the first occasion with neither food nor shelter. Towards the plain of Madura these hills present a precipitous ridge and a steep slope cut into gorges. The south edge of the Palnis here has the appearance of a wall 6,700 feet above the plain with a slope cut into ridges ending in the plain at only 3½ miles from the top. In the other parts the ridge still has a precipitous front, but is more irregular, varying in height from 8,600 to 4,600 above sea-level and showing some fine points. The Travancore boundary runs through this country southward to the south-west corner of the Palni hills, and then west, south and south-east along the watershed of this ridge. To the west of the ridge, that is in Travancore, the ground falls in steps from 8,600 to 4,000 feet above sea-level, forming small irregular plateaux and valleys.

The hills are nearly all grass-covered at top, generally with forest (locally called *sholei*) on the sides. Misapuli, the highest, is a point at the side of a table-topped hill about the middle of the work, and is 8,654 feet above the sea-level.

There are four small villages and a migratory village of hillmen in the area topographically surveyed, and there are also five cinchona plantations with resident planters.

There are three passes from the plain to the plateau. One of these is directly north of Bodináyákanúr. This in its upper part is very steep, looking from below like a wall of rock, and men walking along the path on the face of it seem as though they must fall off. The path is secure enough when one is on it, but it is as rugged as a watercourse and in the wooded parts is obstructed with branches of trees and undergrowth. The distance to the top of this pass from Bodináyákanúr is about 10 miles, but, on account of its steepness, the top is usually reached on the second day. It is only practicable for men on foot.

The Kotagudi pass is north-west of Bodináyákanúr, whence to the Travancore boundary is about 15 miles. The road for the last three miles is very steep but open. At a mile from the top it divides, the right-hand path going to the Vátarvádi villages, the left to two cinchona gardens. Goods are carried by cattle, ponies and donkeys, but the pass is not suitable for riding. The Kotagudi valley, through which the road runs, is very much shut in, and on that account is so very unhealthy, that the people in the neighbourhood say, that any one not born in the pass who drinks the water or sleeps there at night gets fever in three days.

To the west of Bodináyákanúr and about 7 miles thence to the ridge which forms the Travancore boundary, is a pass, for the improvement of which Government has made a small grant, and something seems to be doing towards spending the money. This is the easiest of the passes, the top being little more than 3,000 feet above the plain at the foot and the direct distance from top to foot 2 miles, which becomes 3 by the winding of the road. It is passable for horses, doolies and any baggage animals except laden elephants. At about a mile to the west of the top the road branches, the right branch going to cinchona gardens about Devikolam, the left to Chandanpáre, where the Raja of Travancore has a customs-house during the cardamom season. There are also small custom posts kept up in this and the Kotagudi pass, where dues are taken for Travancore on salt, cardamoms, and cinchona bark. Carts can go to the foot of the north and east passes and to about three miles up the Kotagudi valley. There are other paths, besides those mentioned above, crossing the hills in various directions, and a bridle path from Kodai Kánal winds along the south edge of the Palni hills.

There are no rivers but there are numerous small streams, some of which join to form a stream called here the Periyár, but it is only a branch of that river which rises 50 miles further south, and being joined by this stream, turns westward to fall into the sea north of Cochin.

Omitting the garden coolies, who are most of them semi-resident, coming when wanted from the villages in the plains, there are very few inhabitants in this bit of country. The corner of the Palnis has none. Bodináyákanúr owns the hamlet Kotagudi with 15 houses and about 70 inhabitants. There are three villages of altogether 46 houses and 230 inhabitants in the Vátarvádi valley, and the migratory village of hillmen consists of 10 houses and about 40 persons. Approximately the population is 340 persons old and young, or 2 to the square mile, and they are physically a poor lot.

They have no particular customs to speak of, nor is there anything of archæological interest, except a few upright (perhaps) memorial stones, which the present inhabitants can tell nothing about.

Of natural exports there are none except a little honey and wax, and the fire-wood which the villagers cut for themselves. The cardamoms grow, both wild and semi-wild, in the country immediately to the south in cleared patches in the forest. Elephants, tigers, leopards, bison, sambur and ibex are found in these hills. The forests which are infested with leeches abound in Rhododendrons and tree-ferns.

The grass on the hills is mostly spear grass two feet high. This is very dry from January to March and is then burnt, and as there is generally a pretty strong wind blowing, camping is rather risky work at that time. The burnt stubble also makes a nasty camping place, the ashes worry one's eyes and a dewy morning walk leaves one with legs like a chimney-sweep's.

Of forests, there are none left in this corner of the Palni plateau. In the rest of Madura, that is, the slope towards the eastern plain, about a third of the area is forest, the more accessible slopes being bare. In Travancore about a third of the area is forest. The hillmen used to clear and burn this in patches for cultivation, but they are now forbidden to cultivate any but the grassland, as the forest land has become saleable for cinchona cultivation, and the forest is being rapidly destroyed where the aspect is favourable for that cultivation.

Cinchona bark is the only cultivated export, and is as yet a new production. The people grow only enough grain to feed themselves and to pay their taxes. The gardens are supplied with food from the Madura district, and as the load which the miserable donkeys and ponies can bring up is very small, the cost of the supplies is high; at the beginning of the year, rice selling at 12 seers in Bodináyákanúr, cost the planters a rupee for five seers.

The hillmen keep buffaloes, which they graze on the hills, and in the neighbourhood of these people milk can be bought; otherwise nothing is to be had. All food must be brought from the plains. The Vátarvádi people keep cows but graze them in the Wynaad in the dry weather.

The climate of the hills is pleasant in the winter and apparently salubrious, but in spite of precautions I and most of my men got fever. This I attribute to the water which those in camp must drink from the streams that are at hand. These streams usually have wooded courses and the water is often of a suspicious brown colour. In the winter months, a continuous strong wind blows, which often brings clouds to the mountain tops, which interfere much with surveying. The wind also is often so furious as to prevent work, and twice it wrecked my umbrella and once tore to pieces my *kalasis'* tent. In the spring it blows from the north-east and is very dry and cold, peeling the skin off one's face and hands in flakes. I only know of the climate in the summer from hearsay and was informed that then the wind is equally strong and feels even colder, as it drives a cold stinging rain before it. There is frost on the hills in winter, and in February I found the thermometer at 8,000 feet showed min. 35°, max. 69°. sun, 82.°; at 4,000, min. 50°, max. 80°, sun, 100°; and on the plain below min. 75°, max. 95°, sun, 110°.

The only carriage for these hills is coolies. Mr. Mills tried ponies but gave them up after one trial. The coolies were procured from Bodináyákanúr. They were lazy and insubordinate, could or would only carry half a load for half an ordinary march, and were difficult to get at 8 annas a day. In fact, no man thereabouts will work at all, if he can help it as long as he has a wife or family to support him.

Extracts from the Narrative Report of LIEUTENANT-COLONEL G. STRAHAN, R.E., *in charge No. 21 Party,—Season 1886-87.*

NICOBAR ISLANDS.

Modifications of usual procedure.

As the survey was to be confined to one season, it followed that the usual procedure under which the first season of a new survey is spent in triangulating and preparing for the subsequent work of the detail surveyors, must be abandoned; and it became necessary to devise some system by which the detail work could be carried on without previous triangulation and be subsequently fitted on to it, so to speak, after the computations had been completed in recess quarters. Computation in the field, sufficiently approximate, could not be undertaken without loss of valuable time, every day of which was precious, partly because there were no elements of latitude, longitude or azimuth on which to base them, except such as could be measured off from the charts (confessedly very inaccurate) with compasses, and partly because the weather was so wet and cloudy for several weeks after our arrival at the settlement that astronomical observations to determine these elements were impossible.

It will contribute to the methodical arrangement of this report if I explain here the system I adopted, before proceeding to the detailed account of the share taken by each member of the party in carrying it out.

Requirements of survey.

It appeared that the requirements of the survey were four in number, *viz.*,—*first*, an accurate survey of the coast lines of each of the principal islands; *second*, correct determination of the position of the Nicobar group on the earth's surface including their relative positions *inter se; third*, as much topographical detail of the interiors as could be secured; and *fourth*, an enlarged plan of the settlement itself and its environs in detail, carefully contoured on the same principle as that employed by Captain Hobday at Port Blair. I will take up each of these requirements in order.

Coast traverses.

First—An accurate survey of the coast lines of the principal islands. This was accomplished by what may be called "the subtense bar method," introduced into the Survey Department by Colonel Tanner. When first beginning this system of traversing, I felt somewhat in the dark as to what reliance could be placed on its accuracy, and I therefore commenced on the comparatively small island of Nankauri, which is about 26 miles round. This traverse closed absolutely without visible error on the scale of 1 inch to 1 mile. There was no doubt something of a happy chance about this, as most of the other circuits do show appreciable error. Thus the Little Nicobar, 43 miles round, has a closing error of ·25 mile. The Great Nicobar, 120 miles in perimeter, has one of ·51 mile. On the other hand, Kar Nicobar, 30 miles round, closes within ·06 mile.

Closing of circuits.

Provision was made for adjusting these errors by fixing points in the circuits either astronomically or by triangulation; the errors were judiciously distributed and the traverses fitted on to these fixed points. I have little doubt that the circuits would have closed well in every instance under more favourable circumstances, but it must be remembered that in many cases the plane-table and the theodolite had to be set up in most awkward positions—frequently in the sea with spray dashing over them, or on slippery and uneven rocks, the subtense bar being often partially obscured by the spray of the never-ending swell on these coasts.

Building of observatory.

The second requirement, *viz.*, the correct determination of the situation of the islands of the Nicobar group on the earth's surface, necessitated astronomical observations of latitude, longitude and azimuth, and also a network of triangulation emanating from a measured base. At the settlement of Kamorta I erected a wooden observatory over a large masonry platform which was intended to serve as a permanent mark or zero on which the elements of the survey depend. In order to secure the platform from injury and to identify it in future, it has been placed under the care of the Settlement Officer, and a stone slab bearing the following inscription let into the masonry: "G. T. S. The position of this stone was found from observations made by Lieutenant-Colonel G. Strahan, R.E, in 1887, to be N. Latitude 8° 2′ 21″ ·03 and E. Longitude 93° 31′ 55″ ·05."

Latitude observations.

At this point an astronomical latitude was carefully measured by the method of circum-meridian altitudes. An equal number of stars north and south of the zenith were employed, and an equal number (or very nearly so) of observations face right and face left secured. To avoid the loss of time involved in changing face between every two observations of a star as it crossed the meridian, I made all the observations on each star as it passed without changing face at all, then reversed the instrument and observed the next star on that face throughout, and so on. I found in this way that I could get much more work into a given time without sacrificing any principle, which is a most important consideration in such a climate as that of the Nicobars, where cloudless skies are few and far between. I had no difficulty in securing ten intersections of a star including the reading of four verniers for each intersection in 9 or 10 minutes, thus for the most part obtaining observations within 5 minutes of the meridian either before or after, saving thereby an appreciable amount of labour in the subsequent reductions. Only Nautical Almanac stars were observed. The instrument used at this station, and at all others where the latitude was observed, was a 14″ theodolite by Troughton and Simms.

Longitude of Kamorta and instruments employed.

The longitude of the observatory at Kamorta was determined differentially from Chatham Island, Port Blair, by chronometers. For this purpose I obtained from the Mathematical Instrument Office in Calcutta two excellent transit instruments by Troughton and Simms of about 30″ focus of almost identically the same pattern, and six chronometers, in addition to which the three chronometers of H.M. I.M.S. *Kwangtung* were placed at my disposal. Of these nine chronometers six gave good results, two indifferent, and one was broken at the outset, and consequently took no part in the proceedings. The longitude depends therefore on eight chronometers which were carried three times between the stations, *viz.*, twice from Chatham Island to Kamorta and once from Kamorta to Chatham Island. The weak point of chronometric determinations of longitude is well known to be the uncertainty of their rate during transport from one station to another. In this particular case the voyage though a short one was somewhat too long to admit of transits being observed on one night at one station, and on the next night at the other: one night always intervened. Of the eight chronometers employed, seven solar ones remained always undisturbed in padded boxes on board the ship in as nearly an uniform temperature as possible. The eighth, a sidereal one, was used in the observatories and carried backward and forward as occasion required, comparisons being made with the others either before or after work (or both). The sidereal chronometer was selected for comparison merely for convenience, as its ½-second beats would be synchronous with the ½-second beats of a solar chronometer, about once in every three minutes.

Method of determining longitude.

The method of proceeding was as follows. Transits of eight or ten stars were observed at (say) Chatham Island for two or three nights in succession. Hence the correction of the sidereal chronometer at certain epochs was deduced, as well as its rate from night to night. By means of its rate, its correction at any other epoch could be obtained. In order to determine the corrections and rates of the seven solar chronometers which remained on board the ship, the correction of the sidereal one was computed for the seven epochs at which the comparisons had been made; hence the true sidereal time of comparison was known, and from this follows by a short computation the true mean time, and hence the corrections and rates of the mean time chronometers are obtained. On reaching the other station Kamorta a similar process was carried out; and the rate of each chronometer during the voyage, which enters directly into the longitude, was assumed to be the mean of those found at the first and last stations. The deduction of the longitude then follows very simply, thus :—

Let τ_1 = chronometer time of observation at 1st station.
τ_2 = " " 2nd "
$T = \tau_2 - \tau_1$
α_1 = chronometer correction at time τ_1 at 1st station,
α_2 = " " τ_2 2nd "
m = mean daily rate correction.
ω = longitude of 1st station — longitude of 2nd station.

Then $\omega = \alpha_1 - \alpha_2 + mT$, each chronometer furnishing a separate value on each voyage. It had been originally intended that there should be two voyages at least in each direction, but the weather was so uniformly unfavourable and time so pressing, that I had to be content with two from Chatham Island to Kamorta, and one from Kamorta to Chatham Island. There are therefore in all twenty-four independent values of this difference of longitude, the probable error of the mean being ±0·11 of a second of a time. The two little transit instruments proved to be very handy and serviceable, and very stable in their adjustments. The chronometers employed were the following :—

No. 391 solar, by McCabe from M.I.O., rate very steady.
" 466 " " " " indifferent.
" 1601 " Cummins " " very steady.
" 2684 " Fletcher " " fair.
" 1509 sidereal, Arnold and Frodsham from M.I.O., rate indifferent.
" 228 solar, Shepherd H.M.S. Kwangtung, rate very good.
" 522 " Baker " " " "
" 1032 " McCabe " " " fair.

The longitude of the Chatham Island Observatory was taken at 92°·42′44″·00 which is the value obtained from 41 lunar culminations and 180 lunar zenith distances by Mr. Nicholson of the G. T. Survey in 1861.

Azimuth observations.

An azimuth was measured at the Kamorta Observatory by the usual method of observations to a circumpolar star at elongation. As the triangulation is not of large extent, nor of extreme refinement such as is aimed at in geodetic operations, it was considered that observations to Polaris at one elongation would give sufficiently good results.

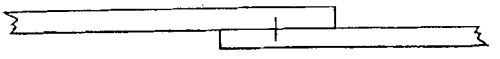
Selection of Base-line.

The observatory at Kamorta is connected by triangulation with the base-line, the measurement of which I will now proceed to describe. A suitable site was very difficult to obtain: the locality ultimately decided on is situated about four miles north of the settlement of Kamorta, on some low undulating hills which are free from jungle. They are however much cut up by swamps, the crossing of which entailed considerable labour in the preparation of the base-line. Its length is approximately 1,000 yards, the eastern extremity being 55 feet higher than the western. The measurement was made under great

difficulties, very heavy rain fell during the first day and converted the ground into a black quagmire ankle deep, and smelling horribly of decaying vegetation. As the rain is almost incessant at that time of year (November and December) it was no use waiting, and we had to make the best of it, but the inevitable fever prostrated a number of men in consequence.

First measurement of Base-line.

The process of measurement was carried out with well-seasoned bars of teak, 10½ feet in length and 3 inches square in section. These bars were carefully planed and squared: a length of 10 feet taken off from an iron standard supplied by the Survey Office in Dehra was laid off on each bar, the extremities of the 10-foot length being marked by a finely cut transverse line. The measurement was effected by bringing into coincidence the transverse cut of the preceding end of one bar with that of the following end of the next one, the bars being placed alongside of one another thus:—

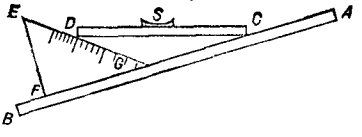


The alignment was given by a 7″ theodolite. The base was measured twice, the process being somewhat different on the two occasions. During the first measurement each bar was individually levelled by means of blocks of wood and small wedges placed under the ends until a spirit-level laid upon it showed the horizontality to have been secured. This was found to be a very tedious and inconvenient proceeding, on such soft and swampy ground, especially as the undulations are considerable. Moreover, during the process of wedging there was an appreciable risk of disturbing bars previously adjusted.

Second measurement and improvements introduced.

During the second measurement the following plan was adopted with great success, the time occupied being reduced from seven hours to four, while at the same time the accuracy was in all probability increased. It occurred to me that if some simple apparatus could be devised by which I could, instead of levelling each bar, measure its inclination, so as to be enabled to compute the amount to be deducted from each in obtaining the true length of the base, that all wedging up might be dispensed with and the bars placed sufficiently level by eye alone. For this purpose, I constructed a large wedge of teak about 2½ feet in length and 1½ inches thick carefully smoothed and planed, and also a teak rod 6 feet long and 1½ inches square in section, on which at the middle of its length was mounted a spirit-level with its axis parallel to the rod. This rod, bearing the spirit-level, was laid longitudinally along the upper surface of a measuring bar when placed in position, and one end of the rod was gradually raised by the insertion of the wedge beneath it until the spirit-level showed it to be horizontal. The end of the rod resting on the wedge then pointed to a number on a scale on the edge of the wedge which was so contrived that that number represented the length in thousandths of a foot to be deducted from the length of that particular bar due to its dislevelment.

In the diagram, AB is the measuring bar, CD the rod supporting the spirit-level S which



is levelled by the insertion of the wedge EFG, on the edge of which is a scale so divided that at the point D where the rod touches it, is a number corresponding to the deduction to be made for that particular inclination of AB. This scale is obviously not one of equal parts, but still the dividing of it presents no practical difficulty. It may be as well to mention here that the angle of the wedge, on which the size of the scale divisions partly depends, must be greater than any angle at which the measuring bars are likely to be placed, but with this proviso the smaller it is the better, as the scale divisions will increase in magnitude as the angle diminishes. The angle of the wedge actually used was made without any definite design, and when subsequently measured turned out to be 16° 30′ and answered its purpose well.

Graduation of wedge scale for Base-line.

The graduation of the scale is based on the following principles; if a bar of length a be placed at some definite inclination θ to the horizon, then its projection on the horizontal plane is shorter than itself by the quantity a versin. θ: in other words if this bar be used as a measuring instrument at this inclination we must subtract this quantity a versin. θ from its length. The scale was divided to show thousandths of a foot and by estimation ten-thousandths.

Now suppose the angle of inclination θ to be such that n thousandths of a foot have to be deducted to obtain the value of the projection on the horizontal plane. Also let the length of the measuring bar be a, the length of the rod carrying the spirit-level be b and the angle of the wedge α.

Then we have $n = a$ versin. θ

and in the triangle CGD, $\mathrm{GD} = \frac{\mathrm{CD}}{\mathrm{Sin.}\ \alpha}\ \mathrm{Sin.}\ \theta = \frac{b\ \mathrm{Sin.}\ \theta}{\mathrm{Sin.}\ \alpha}$

from which two equations the value of GD, *i.e.*, the point at which the number n should be

placed, is determined. This being done for successive values of n, the scale may be constructed. In the present instance CD= 6

AB=10

EGF=16° 36,′

whence we have 10 versin. $\theta = \cdot 001\ n$

or versin. $\theta = \cdot 0001\ n$

and GD (in inches) $= 252 \cdot 02$ Sin. θ

The values of θ are tabulated for $n=1$, $n=2$, $n=3$, &c., whence the corresponding values of GD are obtained.

Remarks on measurement of Base.

This wedge contrivance is obviously open to some theoretical objections such as flexure of the measuring bar, or of the rod supporting the spirit level which would prevent the true inclination to the horizon being measured, as the spirit level would give different indications according to its position on the bar. The level itself was firmly fixed once for all on the rod, so that no subsequent adjustment was possible, and this condition of things might at once be objected to by a surveyor in search of extreme theoretical accuracy. It is only necessary to point out that considerable inclinations of the bar produce very minute corrections to its length, to prove that such objections are of little or no weight where extreme refinement is not aimed at. Thus it requires a dislevelment of a 10-foot bar to the extent of 49′ before the deduction on account of slope amounts to $\frac{1}{10000}$ of a foot, and a level if carefully adjusted could never be in error to such an extent as 49′. Notwithstanding such theoretical objections as these, the method was found extremely convenient in practice and well adapted for a topographical survey. Five bars, constituting one set, were placed simultaneously; the whole length of the base required 59 sets, 4 bars and a fraction. By the first measurement the length of the base was found to be 2,994·770 feet and by the second (which is probably the more accurate, and to which double weight has been assigned) 2,994·595. The final adopted value is 2,994·653.

I will now proceed to the narrative of how these several operations were carried out and the part taken in them by the various members of the party.

Preliminary preparations and voyage to Kamorta.

One assistant, Mr. D. Campbell, was sent down to the Nicobars by the mail steamer of October 22nd to make arrangements for the supply of convicts, masons, building materials, base-line bars, &c., and also to select and prepare a site for the base-line. The rest of the party followed in the mail steamer of November 19th. We were delayed two days by encountering a cyclone in the Bay of Bengal, but reached Port Blair without mishap on the 24th idem. The Chief Commissioner, Colonel Cadell, being in England on leave, I discussed with his successor, Colonel Wimberley, the requirements of the survey, and the best means of carrying them out. Two of the Indian Marine steamers, *viz.*, the *Kwangtung* and the *Nankauri*, with all their boats were placed at my disposal, as well as a batch of convicts, who would be required for various kinds of manual labour. On the following morning we again embarked and reached our destination, Kamorta, on the morning of the 26th November. I found Mr. Campbell had not suffered from the almost incessant rain which generally falls at this time of year, but his work of selecting and preparing a base, and building stations had been considerably retarded. By December 4th the ground had partly dried, and the first measurement was made, the intermediate days having been employed in unpacking and adjusting instruments, mounting plane tables, testing compasses, preparing base-line bars and trestles, &c., &c.

Prosecution of the work.

After December 4th heavy rain again set in and it was impossible to proceed with the verificatory measurement. I therefore with the assistance of Mr. Keating commenced the traverse of the coast of the island of Nankauri. On the 11th I went to the island of Bompoka, and having selected a station there returned the next day to Kamorta. I may as well mention here once for all that I was forced to give up any idea of clearing hill tops of jungle to serve as stations. The forest is so dense, and the hills so difficult to approach, that each clearing would have occupied several weeks, and I had neither men nor time for such work. Fortunately I found a few bare hill tops on Bompoka, from which most of the other islands of the central group are visible, and here I planted a station which subsequently proved of the greatest value. By December 13th the swamps had sufficiently dried up to enable me to carry out the second measurement of the base. On the 15th I left Kamorta for the island of Kar Nicobar with Mr. Keating to start him on the coast traverse there, as he had already gained some experience in this work whilst working with me on the coast of Nankauri. I left him there on the 17th idem and then steamed round the island of Batti Malv to ascertain if it were possible to land on it as it would be necessary to fix its position by astronomical observations. Not being successful I returned to Kamorta, and finding the observatory which I had ordered to be built there nearly ready, I took out and adjusted the transit instrument, measured its wire intervals and value of level scale. On the following day I completed the circuit of Nankauri, which had been left unfinished, at the same time instructing Mr. Campbell in the subtense bar method of traverse. From December 28th to January 5th I was engaged in observing transits at Kamorta and Port Blair with a view of determining their difference of longitude, but was much hindered by bad weather. On January 6th I took Mr. Campbell to the island of Tilanchong to work the coast line traverse and left him there, and returned to Kamorta. On the 9th I inspected Mr. Keating. The rest of the month was occupied partly in observations for latitude at Kamorta, and partly in traversing the coast line of the island, which proved an extremely difficult job.

Difficulties encountered.

It was rarely possible to land at all from the boats direct; the only practicable method was to anchor the boat just outside the surf and then

either wade or swim ashore. Except just when a heavy roller came in, the water was only about 4 feet deep, and the men could stagger along, but the surf went often completely over their heads, much to the detriment of the instruments and plane tables. This process had often to be repeated 10 or 12 times a day, and for days together not one of the party ever had a dry thread on them. Five times during the season my boat was completely capsized in the breakers, but fortunately on no occasion was there any loss of life. The coasts being very dangerous owing to want of reliable charts, much time was lost in rowing ashore from the ship in the morning and out again in the evening after work, as she was always obliged to keep out at a safe distance, the currents and tide rips being very strong and the swell generally very heavy.

Proceedings at southern group.

After completing this I started for the southern group comprising the islands of Great and Little Nicobar, Kondul and several small uninhabited ones. The Little Nicobar coast traverse was allotted to Mr. Keating and the great Nicobar to Messrs. Campbell and Senior. I intended to observe for latitude at convenient intervals along the shore as a check on their traverses, and to utilize my ships the *Kwangtung* and *Nankauri* in moving their camps along the coast as the traverses proceeded, no land carriage being available, and this course I found a very convenient one and economical of time. The weather was horrible, scarcely a day passed without heavy rain, and my observations were much hindered in consequence. I eventually succeeded in getting five latitudes, *viz.*, one on the west coast, one on the south, one on the east, and two on the north. I then laid out some triangulation in St. George's Channel which divides the Great and Little Nicobars, leaving Mr. Keating to measure a short base with the chain to ensure our obtaining correctly the breadth of the channel and the relative situation of the two islands. It now became necessary to return once more to Kamorta as the monthly mail would arrive on the following day, February 17th, and much office work and correspondence had to be brought up. I was engaged from that time till March 4th in making another voyage to Port Blair and back, for chronometric difference of longitude: on the 5th I inspected Mr. Campbell at Tilanchong, and tried unsuccessfully to find Mr. Keating on Teressa. The next day I succeeded in landing on the island of Batti Malv and observed the sun for latitude, and proceeded afterwards to Kar Nicobar, which I reached in time to secure star observations for latitude the same night. They were continued the next night as far as clouds would permit.

Proceedings at Little Andaman.

During my previous visit to Port Blair I had arranged with Colonel Cadell, the Chief Commissioner, who had returned from leave, to meet him on March 8th, at the south end of the Little Andaman to fix the latitude there and to partly overhaul a traverse of the island which had been made by Mr. Portman, one of the settlement officers at Port Blair, and which disagreed so grossly with the published charts of the island that some examination into the matter was most important. A traverse of the northern part of the island had been commenced by Mr. Keating in the previous season starting from an intersected point of the Andaman triangulation, which certainly showed that the Little Andaman is incorrectly placed on the existing charts. Mr. Portman's traverse seemed to indicate that the error in the south was considerably less. In order to elucidate this point I measured one latitude at the extreme north and another at the extreme south of the island. The former agreed very fairly well with the intersected point alluded to, showing the error of the chart to be no less than +4′ 50″. The latter proved the error at the southern extremity to be +1′ 50″. The traverses were corrected accordingly and a fair outline of the island secured. Whilst I was engaged on this, Mr. Senior revised a portion of Mr. Portman's traverse. Surveying on the Little Andaman is by no means unattended with danger, owing to the hostility of the savages.

Hostility of Natives.

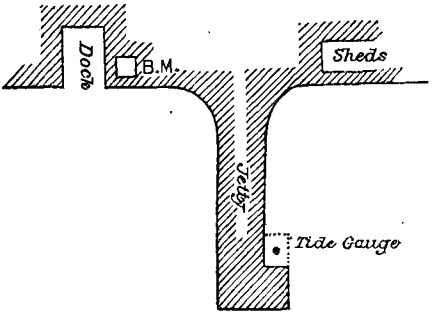
It was supposed that through the exertions of Mr. Portman, the Settlement Officer, that they had been pacified; it seems, however, that this is not really the case, as Mr. Murray, the Chief Engineer of the *Kwangtung*, was attacked, while walking along the beach, by one of them, and dangerously wounded by a blow from an axe on the back of his head. The assault was utterly unprovoked, and it was impossible to guess at the savage's motive in committing it. Fortunately the others showed no intention of joining in the attack and the man was secured without difficulty and taken off to Port Blair.

The remainder of the season was taken up in observing two azimuths, one at Kamorta and the other on the northern coast of the Great Nicobar; also in observing at some of the stations of the main triangulation, in arranging for recording the rise and fall of the tide at Nankauri at intervals of 15 minutes day and night for 33 days, in inspection, and in a third and final voyage for obtaining the difference of longitude of Kamorta and Port Blair. The observations were brought to a close at Port Blair on 19th April.

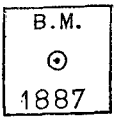
Description of tidal apparatus.

The means by which the tidal record was obtained were as follows. A graduated pole was planted vertically near the end of the Kamorta jetty in shallow water, and secured by guy ropes. The scale on it was laid off from a steel tape which had been previously compared with a standard bar. For convenience of reading, the feet were alternately black with white graduations and white with black graduations. A strong mark was made at every three inches, and smaller ones denoted the single inches, the halves and quarters were estimated. A hedge of cocoanut stalks and leaves was built round the pole, forming an enclosure about 25 feet square to keep off the swell, but not sufficiently

thick to retard the rise or fall of the tide within it. The clock used was compared and set every morning at 8 A.M., with a very reliable one at the bungalow of Mr. Man, the Settlement Officer, which in its turn was set weekly to true time by a chronometer regulated by means of transit observations at the Kamorta observatory. The tide gauge zero is 9′ 7″ below the surface of a masonry bench-mark near the land end of the jetty, which bench-mark serves for the zero of heights for the Nicobar survey, its height above mean sea level being assumed provisionally at 6 feet. The record was kept by two convicts sent down from Port Blair for only that purpose, *viz.*, Abdul Rahmán, No. 5405, and Mehar Bux, No. 5213, under the superintendence of Sub-Surveyors Harlal Singh and Ali Nawáz Khán. It gives the height of the water at every 15 minutes day and night for 33 days, *viz.*, from March 12 to April 13, both inclusive. Arrangements have been made with the Settlement Officer, Mr. Man, for resetting the graduated pole if required at any future time, so as to preserve exactly the same zero it had during these observations. The position of the tide gauge and bench-mark are shown in this diagram.



The stone on the bench-mark is thus inscribed:—



Difficulties of the survey.

The survey of the Nicobar Islands certainly presented exceptional difficulties. There is no mode of carriage except by boat or by coolies (which must be provided by the survey party) along the sea beach, which, however, is so rough and steep in many places as to be impassable. Supplies are nowhere to be obtained, there are no villages worthy of the name, nothing but a few isolated huts on the shore from which the natives generally fled in terror on our approach. The forests on most of the islands are hopelessly impenetrable and the lowlands so cut up by swamps as to be inaccessible. It unfortunately happens that the groups of islands are in many cases at such distances from each other, that the shores are concealed from each other by the curvature of the earth, while the inaccessible hill tops are still visible, and this necessitated more astronomical work than would otherwise have been required, as in many instances the triangulation could not be extended from one to the other.

River scenery, &c.

The scenery, especially of the Great and Little Nicobars, is of indescribable beauty. There are several rivers in the former island which are navigable by rowing boats for some miles, notably the Galatea river on the south coast up which Mr. Campbell penetrated nearly twenty miles. Its course is very tortuous, the banks are fringed with tree-ferns, canes, bamboos and tropical vegetation of infinite variety, through which occasional glimpses are obtained of high mountains in the interior clothed with dense forest to their very summits, and generally cloud-capped. The stream is deep and sluggish with steep muddy banks and contains abundance of fish. The country through which it runs is almost uninhabited, a few huts appear here and there tenanted by an inland tribe of savages called "Shom Pen," of whom very little is known except that they are in such an utter state of barbarism as to be held in contempt even by the Nicobarese inhabiting the coasts. On most of the islands the forest grows luxuriantly close down to the beach and indeed is in many places washed by the sea at high water. Mangroves, except on the island of Kamorta, are not very plentiful, and in this respect these islands differ widely from the Andaman group, where the creeks are fringed with mangroves mile after mile. The sea beach consists largely of coral, and those who have never seen living coral washed by water of such

marvellous purity as the Nicobar seas, can form no idea of the wonderful beauty of the forms and colours displayed by it. Shells too of every shape and hue abound on these coasts, many of them being, I believe, highly prized by conchologists.

Climate.

The climate is most pleasant to one's feelings, being very equable day and night, summer and winter, like most tropical islands, but unfortunately its character for unhealthiness is only too well established. Fever, especially among newcomers, is always prevalent: at times I had 70 per cent. of my men laid up with it, and very very few of the establishment have been altogether free from it. It does not seem to be of a very fatal type, for, with the exception of Sub-Surveyor Harlal Singh, there have been no casualties; but it is most difficult to shake off its effects, and many of my men have been more or less incapacitated from it during the whole recess.

Rainfall.

The rainfall, which averages about 100 inches, is pretty evenly distributed throughout the year. December and January are reckoned the driest months, but during the past season we rarely had more than one or two days free from rain even at that time, and while I was at the Great Nicobar, showers, and very heavy showers too, were of almost daily occurrence. The thermometer stands pretty steadily between 80 and 85 in the shade and hardly varies day or night. The temperature of the sea-water is about 81.

Inhabitants.

The inhabitants of these islands are allied to the Malays. They are very strong, thickly built men, not much if at all inferior to Europeans in physique, of a reddish brown colour, and in every way totally distinct from their near neighbours the Andamanese. The latter are intensely black with woolly hair, and are among the tiniest races of the globe, very few of the men reaching 5 feet in height. The chief characteristic of the Nicobarese savages is unconquerable laziness, which is perhaps not very much to be wondered at. As far as their limited intelligence goes, they have everything they can ever want close at hand. If hungry they have only to eat the pandanus fruit hanging ready to their hand or knock down a cocoanut, and if thirsty drink its milk. Famines, droughts and wars are things unknown to them; their wants are few and simple and easily supplied. They have no money and hardly care to accept it as a gift, having no use for it. Small services are generally paid for in rum or castor-oil, which they mix together and drink eagerly, or in scarlet cloth which they prize more than anything else. Beads and looking-glasses generally so dear to the savage mind they set no value on. They are a peaceable well-disposed race, and it is to be regretted that they are fast dying out, except on the island of Kar Nicobar, where the population is said to be increasing. They appear to have a really wonderful talent for learning languages. Wherever they come in contact with Europeans or with Indian convicts located at Kamorta, they quickly pick up a certain amount of both languages, besides knowing one or two of the Nicobarese languages of which there are six or seven. They are very fond of taking English names, and I found amongst them men answering to the names of Dandy Jem, Sweet William, Adam Bede, Captain London, and other absurdities of which they are extremely proud. They are somewhat fastidious in their head gear and prefer a discarded cocked hat or *sola topi* to anything of their own manufacture. They are grossly superstitious and worship evil spirits to keep them at a distance as far at least as they can be said to worship anything. Christianity has made absolutely no progress among them. It is currently reported that some 15 Danish missionaries spent twenty years among them without making a single convert. I found it utterly impossible to utilize them in any way for survey work, their incorrigible laziness rendered it hopeless to get them to do anything in the way of carrying loads or pointing out paths. Once or twice I found them useful as pilots but for nothing else whatever. On Christmas Day the Settlement Officer organized some sports in which some Nicobarese together with my *khalasis*, some Sikh Police, Madras Sepoys and lascar crew of the *Kwangtung* engaged, and I found that the savages held their own very well. They were beaten in running by some up-country men, but in the tug of war they pulled over all the teams except the Sikh Police. In putting the shot one Nicobarese was far ahead of all competitors, but for the most part they seemed too apathetic to take much interest in what they evidently considered useless exertion.

It is impossible to help feeling a good deal of interest in such genuine savages as these people are, and it was with much pleasure I listened to the accounts given of them by Mr. Man, the Settlement Officer at Kamorta, who is a distinguished anthropologist, and has studied their habits and language thoroughly, and is now engaged on a book on the subject, which will shortly be published, the interest of which I should be sorry to forestall in any way by adding too much to this report.

Conclusion.

In conclusion, I have only to add that I am much indebted to Colonel Cadell and the various officers under his command for the ready assistance they have afforded me in carrying out this survey, the conditions of which are so different from those usually met with in India,—without their aid the difficulties would have been almost insuperable. More especially I have to acknowledge my thanks to Mr. Man at Kamorta for the ready way in which all the resources of his limited establishment were placed at our disposal. His knowledge of the Nicobarese language has enabled me to give much information in our maps which would have been otherwise quite unattainable.

Extract from the Narrative Report of LIEUTENANT-COLONEL S. H. COWAN, *in charge No. 4 Party,—Season 1886-87.*

BASTI DISTRICT.

LIST OF PAPERS WHICH CONSTITUTE A COMPLETE *MISL* OR VILLAGE RECORD.

Received from the Settlement Office.	Prepared by Survey Establishment in the Field.	Prepared by Survey Establishment in Office.	EXPLANATORY REMARKS.
Khewat, or Hissa Kashi.	...	...	List of proprietors with detail of their respective shares in the village.
Intikhab .	...	...	Abstract showing occupant of each field at last settlement 12 years ago and last year.
	Khewatbadar slip	...	Only prepared when local inquiry shows that corrections are required in the *khewat*.
	Khasra . .	...	Written by the *amin* or *muharrir* in Urdu; areas and page totals, &c., entered in office.
	Jamabandi slips .	...	Written by the *patwári* in Nagri at the same time as the *amin* makes the corresponding entries in the *khasra*.
	Fardhawála .	...	Kept by *amin* to show the number of first entry of each *samindar* and tenant to which subsequent entries are referred, &c., &c.
	Dispute lists .	...	One in Urdu by the *amin* and one in Nagri by the *patwári* to make sure that all claims are duly recorded.
		Trace maps .	One in Urdu on which the various classes of soils are shown by colour and one in Nagri for *patwári*.
		Milán khasra .	Abstract of *khasra* showing details of cultivated area, irrigated and dry, area fit for cultivation, barren area, &c.
		Serial lists of Fields.	Partly prepared in the field by *patwáris*, but generally re-written in office.
		Book Jamabandi	The slips copied into a book after regular arrangement, and entry of areas, &c.
		Terij . .	Abstract of holdings.
		Statement No. 1 (Urdu).	Detailed area statement showing separately assessable lands of various classes, non-assessable, &c.
		„ „ 2	Soil statement, areas of various kinds of soil.
		„ „ 3	Statement of holdings showing separately *sír*, *khúdkasht*, occupancy, tenant-at-will, and areas.
		„ „ 5	Statement of areas under different crops.
		„ „ 6	Caste statement, number of fields and areas cultivated by different castes.
		„ „ 7	Showing classes of soil distributed under the different tenures of the cultivators.
		„ „ 9	Agricultural statistics, number of ploughs, cattle, wells, &c.
		Village statement (English).	Giving the above 7 statements on one large page.
		Statistical Index (English).	In four pages, giving the same in one line for each village with total for each *tappa*.

Extract from the Narrative Report of LIEUTENANT-COLONEL J. E. SANDEMAN, S.C., *in charge No. 5 Party,—Season 1886-87.*

GORAKHPUR DISTRICT.

(1) Statistics of areas and population of Padrauna Tahsil compiled from survey records.
(2) Archæological notes on Buddhist remains.
(3) List of illustrations. (*These have not been reproduced.*)

(1) STATISTICS OF AREAS AND POPULATION.

The Padrauna *tahsil*, the survey of which is now completed, consists of only one *pargana*, Sidhua-Jobna. The names of the 22 *tappas* which it contains, their area and the total number of *mauzahs* in the *pargana* are given below:—

Number of Mauzahs.	Names of Tappas.	Parganas.	Area in acres.	
	Bank Jogni	Pargana Sidhua-Jobna.	33,105·60	
	Bansi Chirgora		43,554·62	
	Batsara		101,879·16	
	Bhalua		13,963·28	
	Bhatahi Badraon		16,755·63	
	Chaura Bargaon		47,533·38	
	Dandupur		15,129·47	
	Dhuria Bijaipur		18,766·89	
	Haveli		40,809·15	
	Jhankaul		13,356·22	
	Khan		16,134·12	
	Mainpur		27,175·08	
	Malsil Saraini		27,511·01	
	Naugaon		18,928·34	
	Pakri Gangrani		9,520·77	
	Papaur		41,164·27	
	Parwarpar		43,577·82	
	Pirthipur		7,043·45	
	Rampur Dhab		18,086·81	
	Rampur Rogha		13,514·62	
	Sandi		15,789·71	
	Sapahi Kuchia		10,260·36	
1,364	. . . . .	. . .	5,93,559·76	= 927·49 square miles.

The total amount of cultivation and of irrigated and dry cultivation in the *tahsil* is as follows:—

	Irrigated		Total.		
	From wells.	From other sources.	Wet.	Dry.	Total cultivation.
	Acres.	Acres.	Acres.	Acres.	Acres.
Sidhua-Jobna	17,126	33,251	50,377	361,584	411,961

The small amount of irrigation is due to the large tract of *bahát* soil, which is cretaceous and retains moisture and does not therefore require irrigation.

The areas of land cultivated by proprietors and tenants in the *tahsil* are as follows:—

	Sir and Khudkásht.	Tenant's land.
	Acres.	Acres.
Sidhua-Jobna	55,774	356,186

The numbers of, and the areas cultivated by, occupancy tenants and tenants-at-will are given below:—

	Occupancy tenants.		Tenants-at-will.	
	No.	Acres.	No.	Acres.
Sidhua-Jobna	93,380	201,102	93,215	147,482

The number of rent-free tenants and the areas cultivated by them are—

	Number.	Acres.
	3,001	7,094

The number of ex-proprietory tenants and areas cultivated by them—

	Number.	Acres.
	148	508

The average sizes of the three kinds of holdings are—

	Acres.
Occupancy-tenants	2·15
Tenants-at-law	1·58
Ex-proprietory tenants	3·43

The culturable and barren areas are as follows:—

Culturable.

	Fallow.	Groves.	Grass.	Bush.	Total.
	Acres.	Acres.	Acres.	Acres.	Acres.
	88,645	11,452	10,822	25,329	136,248

Barren.

	Sites.	Water.	Otherwise barren.	Total.
	Acres.	Acres.	Acres.	Acres.
	9,372	17,970	18,008	45,350

The cultivated areas under the various soils are as follows—

	Dóras (loam).	Matyár (clay).	Balúa (sand)	Bahát (cretaceous soil).	Kachhár (lands inundated in the rains).
	Acres.	Acres.	Acres.	Acres.	Acres.
	66,881	27,192	2,700	303,632	11,556

It will be noticed that *bahát* soil, which requires no irrigation and which is well suited to the growth of indigo and sugar, is nearly three times the area of the remaining soils.

The conventional tracts, as divided for assessment purposes, and to which the rates of rent often conform, have the following areas:

	Goend (home lands).	Manjhár (middle tracts).	Pálu (out-lying).
	Acres.	Acres.	Acres.
	66,288	163,068	182,604

Thus the *goend* tracts are about 16 per cent. of the whole.

The following is an abstract of the agricultural statistics:—

Wells.		Total.	Ploughs.		Total.	Plough cattle.	Other cattle.	Sheep and goats.	Horses.	Village sites.
Masonry.	Earthen.		2 bullocks.	4 bullocks.						
6,661	1,244	7,905	55,188	41	55,229	114,618	179,797	72,673	3,325	4,828

There are 5·21 sites of villages in each square mile.

The following are the areas under some of the principal crops in the autumn and spring harvests:—

	Acres.
Kharif.	
Rice (Aghani and Bhadain)	117,154
Kodo	48,304
Arhar, with jowár and bájra	37,961
Til	202
Makai	38,667
Jowár	3,199
Urd, moth	778
Garden food crops	1,505
Other food crops	14,265
Total food crops of the kharif harvest	262,035
Sugarcane	28,480
Cotton	3,727
Indigo	5,072
Garden non-food crops	11,328
Other non-food crops	2,235
Land prepared for sugarcane	18,346
Land prepared for indigo	4,098
Total non-food crops in the kharif harvest	73,286
Rabi.	
Wheat	61,058
Barley	35,257
Gojai, wheat and barley	42,952
Gram	3,011
Kirao (pulse)	35,616
Potatoes	622
Masúr	13,223
Garden food-crops	564
Other food-crops	326
Total food crops in the rabi harvest	192,629
Opium	6,334
Tobacco	89
Tisi	33,623
Garden non-food crops	1,462
Other non-food crops	956
Total non-food crops in the rabi harvest	42,464

The double-cropped area is = 158·454 acres.

The numbers of cultivators of each caste and the areas cultivated by them are given below :—

	Number.	Acres.
Mahomedan	5,341	11,847
Brahman	25,368	63,544
Rájputs, Thákurs or Chhatris	8,391	27,522
Banya	6,279	11,127
Káyath	2,952	8,494
Chamár or Dusád	18,095	28,917
Ahir	19,512	35,470
Koeri	21,231	49,716
Kurmi	14,386	36,245
Kahár, Mallah or Gondh	7,834	12,303
Dhobi	3,022	4,053
Teli	5,818	9,654
Juláha	14,102	23,958
Nanera	5,437	9,952
Barai	1,127	2,290
Kalwár	3,596	6,708
Nái	3,238	4,475
Bharbuja	41	68
Darzi	413	584
Dhánuk or Dhom	96	61
Christian	140	7,210
Blacksmith and carpenter	5,815	9,912
Goldsmith	1,001	1,233
Other castes	28,058	46,617
TOTAL	201,293	411,960

Beyond giving the above statistics I abstain from making further remarks on the *tahsil*, as it has been fully described at the previous settlement and in the "North-Western Provinces Gazetteer."

(2) ARCHÆOLOGICAL NOTES ON BUDDHIST REMAINS.

The Padrauna *tahsil* has been a Subdivision since 1868.

The head-quarters of the Joint Magistrate are at Kasia, which has been identified as the ancient Kusinágara, and it is remarkable for its Buddhist remains, the most famous of which I have ventured to illustrate by sketches taken by myself and one Ramnarain Bhagat, an old man who is a resident of the Salímpur *pargana*, and whom I discovered going about making his living by taking sketches of indigo factories.

I have affixed an explanatory index to the sketches. The ruins are situated on the western banks of the Ramabhar Tál.

The oblong mound 30 feet high on which the ruined *stupa* and memorial temple are situated is 600 feet long and 200 to 300 feet wide. The conical mound of solid brickwork now overgrown with bushes and trees is 50 feet high. The colossal statue 20 feet long rests within the restored temple where it was originally discovered in fragments.

The other sculpture is situated under a tree a few hundred yards from the temple, it is 10½ feet high and 4¾ broad, the figure is colossal. It is defective as to an arm (if I recollect rightly) which the artist has thought proper to supply. It will explain the interest which attaches to the sketches, which as such have little merit, if I give a brief account of the rise of Buddhism and also short extracts from the account of the discovery and excava-

tion of the ruins. For the facts regarding the former I have had to refer to Monier Williams and others, and for the latter to Vol. XVIII, Archæological Survey Report 1876-77.

Buddha was born at Kapilavastu in the Basti district. Buddha means "the perfectly enlightened one." The family name was Gautama and the father was king of the Sakyas, an Aryan tribe inhabiting the country on the banks of the Rohini, the modern Kohána. Prince Gautama, commonly known as Sakya-Muni (the lion-hearted sage), among reverential Buddhists, was born about 543 B.C.*

He was early married, but there is little record of his youth till his 29th year, when he suddenly left his home to devote himself to a religious life, after having seen a series of visions, abandoning his wife and only son, his home and wealth. The motive for his flight is said to have been love and pity for humanity which caused him to proclaim his doctrine to the world.

Gautama died about 500 B.C.*

Buddhism spread with great rapidity. King Asoka, who reigned about 250 B.C. decreed it the state religion of his kingdom Magadha (Behar). His edicts, enjoining *dharma*, the practice of universal benevolence, are written on stone pillars and are found scattered in many places, and there is more than one such in the Gorakhpur district.

Buddha's teachings were committed to memory by his disciples and thus handed down until at last they were put in writing.

The number of living Buddhists is estimated at 470,000,000, outnumbering the followers of the various Christian churches.

I have called the sketches "Scenes from the Buddhist Holy Land," because not only was the "Great Law Giver" born at Kapila and died at Kusinagara, but many of his wanderings were in these parts, the inhabitants of which were the first to be converted to the new faith.

Buddhism has no theology, but is rather a system of "duty, morality, and benevolence without real deity, prayer or priest."

At a few fanatical centres of Brahmanism Buddhism was in time exterminated by force, but it is probable that generally speaking the two became gradually blended.

In the seventh century A.D. the Chinese traveller, Hwen Tsang, found the two flourishing amicably side by side. The following are a few extracts from the Archæological Survey Report regarding the discovery of the ruins:—

. . . . . .

"As I was actually in search of the famous colossal statue of the Nirvána of Buddha mentioned by Hwen Tsang, it struck me that I might possibly have the good fortune to hit upon some remnant of the famous statue. I ordered a shaft to be sunk perpendicularly downwards into the centre of the mound. After digging to the depth of 10 feet I came upon what appeared to be the upper part of the thigh of a colossal recumbent statue of stone, but which had apparently been repaired with plaster."

. . . . . .

"The statue was lying in a ruined chamber which was about 30 feet in length by nearly 12 feet in breadth."

. . . . . .

"The stone, of which the statue was formed, was sandstone of a mixed colour, mostly dark and clay colour."

. . . . . .

"The total length of the statue was about 20 feet and of the pedestal 24 feet, breadth 5½ feet."
"The thickness of the walls of the temple on a level with the floor was nearly 10 feet."

. . . . . .

"The dimensions of the temple outside were about 47 feet 8 inches by 32 feet. But there was, besides, an outer chamber on the west side, which was about 35 feet 10 inches in length by about 15 feet in breadth outside, with walls about 5 feet thick."

. . . . . .

"I also entirely repaired and restored the *singhásan* or throne."

. . . . . .

"Affixed to the western side of the *singhásan* I found three sculptures, displaying three human figures, each carved in a shallow curved niche cut into a solid block of stone. The left-hand figure was that of a woman with long hair, in a posture of grief, and stooping or crouching forwards, with her hands resting on the ground, which I took to be a figure of Yasodhara, the wife of Buddha. The right-hand figure might be that of either a male or female and was in a sitting position, with the head resting on the right hand, as if in sorrow. I took this to be the figure of Rahula, the son of Buddha. The central figure was that of a man sitting in a squatting position, with his back turned to the spectator, and his face hidden from him, and turned towards the great statue of the Nirvána. On the lower part of the stone of this latter sculpture I was so fortunate as to find an inscription, in two lines, in characters of probably about the second century of the Christian era."

. . . . . .

"But in the inner door of the temple itself I made an interesting discovery. In two hollows, one on each side at the lower part of the doorway, I found the ancient cup-shaped iron pivot hinges of the former doors and adhering to the hinges I found some fragments of black charred wood, which showed that the doors had been destroyed by fire, and as numerous human bones and various charred substances were found in the outer chamber, as well as in both doorways, it was evident that Buddhism had here been annihilated by fire and sword."

"But the temple which I repaired was not the original or most ancient temple . . . . for I discovered that the present temple was closely surrounded on three sides by the ruined remains of the base of

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* Accounts give different dates.

another brick wall which extended from the front along the sides to within 6 feet of the back of the present temple."

. . . . "Besides the flight of steps leading up to the door of the present temple, I also discovered another lower and more ancient flight of steps running down from the west side of the great plinth in front of the temple. These ancient steps were lower than and about 10 feet distant to the west of the steps of the present temple." . . . . . .

"Close adjoining to the east side I excavated a row of small *stúpas*, five in number and of various diameters" . . . . . .

"At the greatest depth reached in the excavations I found a red *terra cotta* figure of Buddha, standing with his right hand raised in the attitude of teaching . . . to the east of the great *stúpa* I found a metal bell with a portion of a thin iron rod attached to it" . . . . . .

"I also found an ancient well at the depth of 10 feet below the surface of the mound, this ancient well was originally square below . . There is now good water in the well and people draw from it" . . .

"It is plain that the present ruined pillar cannot be the one built by Asoka . . . . It cannot even be a secondary *stúpa* which was reconstructed upon the remains of the Asoka *stúpa*, but I believe that the present *stúpa* represents a third structure which was reconstructed upon the same site and upon the ruined remains of the two former successive structures." . . . . . .

"In the other ruined *stúpa* which is situated some distance to the east, are found huge square bricks which must at least be as old as the period of Asoka, if not older, some being 1 foot 4 inches square by 4½ inches in thickness" . . . "it was erected on the spot where Buddha's body was burned."

Kasia (the ancient Kusinagara) was visited in the fifth and seventh centuries by the Chinese pilgrims Fa Hain and Hwen Tsang respectively. The latter says that Budhha died half a mile from the city, which General Cunningham identifies as the spot where the colossal statue is found. The mound where the cremation took place is also identified from the description of the Chinese.

Mounds of bricks are scattered all over the *pargana*. Ancient remains, many of them Jain, are found at other places, such as Padrauna, Saraia (Tappa Haveli), Satiaon and Fazal Nagar (Tappa Jhankaul). Mr. Carleyle, who made the excavations at Kasia, identifies this last named place as the city of Páwa, where Buddha is said to have rested and drank water or bathed before proceeding to Kusinágara on his last journey. No doubt reverential Buddhists would attach great importance to the right identification of such a "sacred" spot.

At the village of Lohangri (Tappa Sapahi Kuchia) are the foundations of an enormous building which can only have been the palace of a King or a huge Buddhist monastery.

When Mr. Edwin Arnold, the author of the beautiful poem the "Light of Asia" visited India two years ago, I wrote to invite him to pay a visit to the death place of Buddha, but he was unable to come, I regret to say. It would have been interesting to visit these scenes in the company of such an enthusiast.

(3) List of Illustrations.

Scenes from the "Buddhist Holy Land."

No. 1. A sketch of the ruins of the memorial *stúpa* built on the spot where Buddha Gautama died or "attained Nirvána." Also of the restored temple, of great antiquity, within which the colossal statue of Buddha was discovered. The cottage on the left of the picture is modern and is in ruins, and has been built on the foundations of an ancient building.

No. 2. A sketch of the ruined *stúpa* built in the third century B.C. on the spot where the body of Buddha was burnt. It is situated on the west bank of the Ramabhar lake. The ruins are close to Kasia, the ancient Kusinágara.

No. 3. View from the platform of the ruined *stúpa* and of the restored temple within which the colossal statue was found and where it now rests.

No. 4. A pen-and-ink drawing of the colossal statue by Ramnarain Bhagat, a resident of the Gorakhpur district.

No. 5. A pen-and-ink drawing of the black stone statue of Buddha seated under the Bodhi tree, and which rests where it was found within a few hundred yards of the *stúpa*. It is also drawn by Ramnarain.

Extract from the Narrative Report of Lieutenant S. G. Burrard, R.E., *in charge Nos. 22 and 23 Parties (Astronomical),—Season 1886-87.*

Latitude Operations.

As the Jubbulpore Meridional Series on which I was operating passes through the mountainous districts of the Central Provinces, and throughout its entire length contains no single plain station, I had much difficulty in selecting stations which would be apparently free from deflection of the plumb-line. The following stations were finally selected for the season's work:—Sarandi Pat, Lingmára, Sitápár, Bhimsain, Rájuli Diwai, Ankora and Burgpaili, but (owing to my recall in March to carry out the experiments with the Transit Instruments) observations were only taken at the first five.

Zenith Sector No. 2 was used in preference to the sister instrument No. 1, owing to the large (N—S) equation shown by the latter when last employed in 1871-72.

The parties moved from Mussoorie to Dehra on October 8th for practice with Zenith Sector No. 1, and on November 5th started for Nágpur. Owing to the delay of the baggage in transit, the difficulty of obtaining new *khalásis* and *kahárs*, and the time consumed in bringing No. 2 Zenith Sector from Poona, work was not begun till November 25th. Having received orders to thoroughly overhaul the instrument before moving out into the districts, I built a latitude pillar at Nágpur and observed for latitude on eight different nights, taking 248 observations: some harassing peculiarities were constantly to be met with in manipulating the instrument, but on working out the results I found them too accordant for anything to be radically wrong, and consequently reported the instrument in good working order.

Whilst at Nágpur, I determined the values of the division scales of the vertical axis and transit axis levels, as also of all the spare levels with the parties. With the exception of the spare levels, these values had been determined before by Colonels Campbell and Heaviside, but both officers had thrown doubt on the correctness of their results. The instrument I used in these determinations was a bubble-tester from the Mathematical Instrument Office, and I found it to give excellent results.

Leaving Nágpur on December 8th I passed Seoni on December 15th, and reached Sarandí Pat, 160 miles from Nágpur, on December 19th. Owing to the pillar being unfinished, observations for latitude were not commenced till 23rd, they were completed on the 31st, and the parties set out for Lingmára the following day and arrived on January 7th: the observations here extending over six nights were completed on January 13th. Sitápár, the third station of observation, was reached on January 18th and work commenced the same night. I was much troubled at this station by clouds, but considered sufficient observations had been taken by January 23rd. I set out from Sitápár for Bhimsain on the following day, but was delayed for ten days at Sákoli, a *tahsil* town *en route*, owing to a disturbance between my *khalásis* and the police.

After setting up the instrument at Bhimsain on February 10th, and levelling it accurately, the steel spanner (used for clamping and unclamping the base-plate screw) unfortunately broke: I was therefore unable to adjust my level, and had to accept whatever error the instrument chose to show. Day by day this error increased until after work on the fourth night, the bubbles passed the 70th division of their scales: in finding the values of these scales at Nágpur, I had noticed that the uniform curvature of the tubes ceased about the 75th division on either side of the centre point: it was useless therefore to continue work, and only four nights' observations have been taken at Bhimsain: moreover, no reversal of the instrument in azimuth was carried out, as it cannot be done without disturbing the level. In spite of the absence of this reversal, the comparative fewness of the observations and the large inclination of the vertical axis, the probable error of the final value of co-latitude was as small as at others, due no doubt to the extremely favourable nights on which observations were taken. The spanner of No. 1 Zenith Sector forwarded from Dehra Dún reached me at Rájuli, my fifth station, where work was commenced on February 24th and concluded on March 1st, and I then marched for the railway terminus at Warora, and left the Central Provinces for Dehra Dún on the 12th March.

Method of observing.

The method followed throughout the season in taking the observations was practically the same as had been adopted by Colonels Herschel, Campbell and Heaviside when observing with the same instrument. The programme for a night's work was made to contain from 32 to 36 stars, and in drawing it up the following conditions were fulfilled:—

(1) All stars were to be selected from the latest Greenwich catalogue.
(2) No star was to be considered trustworthy unless its north polar distance was determined by at least six observations.
(3) 13° was to be the maximum zenith distance allowable.
(4) The number of north stars was to be equal to the number of south.
(5) The mean north zenith distance was not to differ from the mean south by $\frac{1}{4}°$.
(6) Stars of an 8° zenith distance and more were to be paired.

I commenced at Nágpur by observing every star on four nights: on computing out the results I found that the probable error of co-latitude, as given by a single star observed four times, was $\pm 0''{\cdot}40$, whilst the probable error of the mean of the four zenith distances was only $\pm 0''{\cdot}18$. Starting with these data, the following probable errors admitted of easy deduction:—

P. E. of a single zenith distance observation $= \pm 0''{\cdot}360$,
P. E. of an N. P. D. computed from the Greenwich Catalogue $= \pm 0''{\cdot}357$.

The object of my observations being the determination of astronomical co-latitudes, and not merely of zenith distances, it became apparent that the accuracy of the results was as much affected by errors in N. P. D. as by all errors of observation combined, and consequently I deemed it advisable to increase the number of zenith distance observations and the number of stars observed simultaneously. An observer has four nights to devote to each station; with the above computed data as a basis, he can calculate the probable error of the result of his four nights' work, and from this he can see whether it is more advantageous

(1) to observe the same 40 stars on each of the four nights;
(2) to observe 40 stars on the first two nights and 40 fresh ones on the last two;
(3) to observe 40 fresh stars every night.

In each of the three cases the number of observations taken on the whole and the amount of work carried out would be the same. By utilising the results of an immense number of observations, I was able to make the following calculations :—

Probable Error of a co-latitude, deduced from					40 stars, each observed				four times	$= \pm 0''\cdot063$.
"	"	"	"	"	80	"	"	"	twice	$= \pm 0\cdot049$.
"	"	"	"	"	160	"	"	"	once	$= \pm 0\cdot039$.

The result therefore attained by observing 40 fresh stars on each of the four nights will be very much better than by observing 80 stars twice each. It is, moreover, easy of proof, that but slight advantage accrues at all from taking a third zenith distance observation *per* star, and that a fourth such observation is absolutely waste of time.

I had however reasons to suspect that the zenith distance of any star would vary according to whether it was observed with the azimuthal stud north or south and whether it was taken from east to west or from west to east. With this contingency in view I thought it best to observe each star on two nights, with azimuthal stud north on one night and south on the other; if on the first occasion it was taken from east to west, on the second I took it from west to east and *vice versâ*.

For the purpose of investigating the presence of these suspected instrumental errors the latitude at each station has been computed firstly from observations taken with the azimuthal stud north, and secondly from observations taken with the azimuthal stud south. If large differences had been found, it would have been necessary to apply a correction to the final value of latitude at Bhímsain, where (as mentioned before) no reversal of the instrument took place. But the mean value of these differences being only $0''\cdot019$, a quantity less than half the average probable error, we must conclude that the position of the azimuthal stud exercises no appreciable effect on the observations and that any correction for absence of reversal would be superfluous.

For similar reasons the stars have also been grouped, according to whether they were observed E. to W. or W. to E. and the values of latitudes computed in the two cases. It is an extraordinary fact, that on an average throughout the season any star observed W. to E. will give the latitude of the place half a second larger than the same star observed E. to W. Thus the latitude of any station derived from stars observed only W. to E. will be $0''\cdot25$ in excess of the true value, whilst the latitude derived from stars observed E. to W. will be the same amount in defect of the true value. Now the symbols E and W have relation only to the cardinal points, and do not refer to any particular position of the instrument: as far as the instrument itself is concerned, and without any reference to exterior objects the *same* process in changing from *E. to W. with stud north* is gone through as when changing from *W. to E. with stud south*. To gain further information, I combined all observations taken E. to W. with stud north and all observations taken W. to E. with stud south: the resulting latitudes differed from the true values in the mean by only $0''\cdot07$. Similarly I collected together all observations taken W. to E. with stud north and all taken E. to W. with stud south: the results derived from these also differed from the final mean values by $0''\cdot07$. These facts only help to intensify the perplexity of the E. to W. and W. to E. differences; these symbols in reality only indicate the position of the instrument with reference to the Observatory tent, and I am quite at a loss to assign a cause for the discrepancies brought to light.

After the discovery of the E. to W. and W. to E. differences, it will never be possible for the latitude of a place to be determined from stars only observed once each: the probable error of such a result would be $0''\cdot15$, and therefore although as I have shewn the P. E. of a co-latitude determined from 160 different stars each observed once is less than that of 40 stars each observed four times or of 80 stars each observed twice, yet, having regard to the necessity of observing each star E. to W. and also W. to E. the best possible arrangement would seem to be that of 80 stars observed on two nights each.

Defects in instrument.

The necessity of always determining a zenith distance by at least two observations greatly influences the improvements required in the instrument: the mean of two zenith distances is a much more reliable measure than the N. P. D. of the star given by the Greenwich Catalogue. It is of but little advantage to possess an instrument which gives highly accurate values of zenith distance if the N. P. D.'s are unreliable. Provided therefore the necessity of observing every star *both* E. to W. and W. to E. is fully recognised, Zenith Sector No. 2 as it stands at present is more than qualified to answer its purpose. The only improvement that I should like to see carried out, is the permanent attachment of the level tubes to the brass pivots: and this I recommend not with the object of attaining greater accuracy, but simply to relieve the observer of an ever-existing source of anxiety during the field season.

An observer working with Zenith Sector No. 2 is caused much annoyance by uncontrollable changes in the relative readings of the microscopes; it is of importance that the readings of the microscopes B, C, D, should be each some 10 divisions in excess of that of A, and at the commencement of a night's work the micrometer heads were invariably adjusted to attain this object. However, through some defect in the instrument, a constant relationship was not maintained, and numberless hindrances ensued in consequence. Suppose at starting the micrometers of the 4 microscopes are adjusted to read respectively

30, 40, 40, 40: after a very few observations they are found reading 30, 40, 30, 30 or perhaps 30, 40, 50, 50, and after a few more they will have reverted again to 30, 40, 40, 40. I wasted hours in futile attempts to trace the cause of this phenomenon, and it was only towards the close of the field season I satisfactorily discovered what it was. I can unhesitatingly state now that the black counterpoise does not always act with the same pressure, and consequently does not always raise the sectors the same amount with reference to the alidade. This irregularity of pressure must be due either to (1) the levers having longitudinal play and the relative lengths of their arms being thus able to vary; or (2) to the wear of the bearings in the front wall of the cradle, enabling the levers to find two different points as *fulcra;* or (3) to a fault in the relieving wheels, to which the short arms of the levers are attached.

This defect may without doubt be attributed to the serious accident that befell this instrument at Voi in 1872. I have mentioned it thus briefly, as it was a source of great uneasiness in the field, so much so that I considered it expedient to devote 6 nights to each station instead of 4. Having now computed out the final values of co-latitude, I find that it has no visible effect on the results; and if only future observers are fore-warned of the phenomenon, it will always be perfectly harmless.

The irregular readings of the levels caused me much uneasiness in the field; but when they were computed and exhaustively treated, the results arrived at were satisfactory as may be seen from the following table:—

Station.	λ True values of latitude obtained by employing both levels.	λ_a Values of latitude obtained by employing *a* level only.	λ_b Values of latitude obtained by employing *b* level only.	$d\lambda_a = \lambda - \lambda_a$	$d\lambda_b = \lambda - \lambda_b$
Sarandí Pat . .	22°12′50″·706±·047	22°12′50″·750±·049	22°12′50″·660±·047	−″·044	+″·046
Lingmára . .	21°42′55″·409±·053	21°42′55″·457±·054	21°42′55″·360±·054	−·048	+·049
Sítápár . .	21°24′43″·868±·046	21°24′43″·884±·047	21°24′43″·851±·049	−·016	+·017
Bhímsain . .	20°57′28″·595±·045	20°57′28″·485±·048	20°57′28″·704±·045	+·110	−·109
Rájulí . . .	20°12′51″·293±·037	20°12′51″·276±·039	20°12′51″·310±·038	+ 017	−·017
Means .	±·046	±·047	±·047	+·004	−·003

The mean values of $d\lambda_a$ and $d\lambda_b$ are absolutely insignificant; the mean probable errors of λ_a and λ_b are the same, and only 0″·001 in excess of the probable error of λ. The relative worths of the two levels are therefore so nearly equal, that probable errors do not afford sufficiently minute data for comparison: all we learn by their means is that it is better to employ the readings of both levels than those of either one separately, but that even then the advantage gained is so insignificant as to be barely visible. Now if one level was decidedly superior to the other, it would of course be advantageous to entirely reject the readings of the inferior, and the fact that both levels combined give better results than either separately, is a clear indication of perfect equality.

Final results.

The final results of the observations are as follows:—

Station.	Number of stars observed.	Number of observations.	(N—S) equation.	λ_o Astronomical Latitude.	λ_c Geodetic Latitude.	$\lambda_o - \lambda_c$ = Apparent attraction of plumb-line.
Sarandí Pat. .	53	183	+″·380	22°12′50″·706±·047	22°12′55″·61	−4″·90 North.
Lingmára . .	68	182	+·102	21°42′55″·409±·053	21°43′ 3″·07	−7″·66 „
Sítápár . .	66	166	−·186	21°24′43″·868±·046	21°24′50″·54	−6″·67 „
Bhímsain . .	68	134	+·282	20°57′28″·595±·045	20°57′35″·96	−7″·37 „
Rájulí . . .	88	174	+·448	20°12′51″·293±·037	20°12′55″·45	−4″·16 „

The mean (N—S) equation for the season is +0″·205; this is unusually small, and considering that errors in refraction directly tend to produce this equation, I think we may safely assume that Zenith Sector No. 2 is wholly free from the great defect that renders the sister instrument useless.

After the harassing phenomena so frequently met with in the manipulation of the microscopes and levels, I was much surprised at the accuracy of the results finally shewn up by the probable errors; the comparative magnitude of the probable error at Lingmára is due to one refractory star, No. 590, the value of co-latitude derived from which was 1″·78 in excess of the final mean.

The differences between the astronomical and geodetic latitudes shew how impossible it is to even roughly estimate the probable deflection of the plumb-line from the view

of the country round or from the study of maps. At Sarandí Pat I expected a very large northerly attraction, whilst at Bhímsain and Rájulí I saw no reason for supposing a deflection in either direction. At Lingmára and Sítapár the view pointed to northerly attraction, but both stations appeared suitable for latitude observations and very superior to Sarandí Pat.

Electro-Telegraphic Longitude Operations.

These operations consisted of the determination on 16 different nights of the difference of longitude between two stations in Dehra Dún, built on the same meridian and 17 yards apart. The work was purely experimental, its object being to localise the source of the large circuit errors that obtained in the season 1885-86. Mr Eccles and myself were the observers, and the Transit Instruments employed were those that have always been used on this work. The numerous theories that had been broached as to the cause of these errors, formed the basis for our programme, which was so arranged that all the questions hitherto mooted were expected to receive their answers from our results. The various conjectures that had been made may be briefly summed up as follows:—

(1) That our method of determining collimation was erroneous, in that the readings of a collimator cross are sensibly different when taken with uninterrupted vision, and when view is obtained through the aperture in the cube of the telescope, whereas we assume them to be the same.

(2) That the velocity of an electric current from A station to B is not the same as from B to A, whereas our method of reduction is based on the hypothesis that it is.

(3) That personal equation is liable to large and sudden variations from night to night.

(4) That there exist certain natural phenomena, of whose presence and laws we are ignorant, but whose influence on our results is considerable.

(5)(*a*) That the telescopes possess constant residuals which should be allowed for in the computations, but which have never been determined.

(*b*) That the telescopes are so defective in construction that the line of collimation in each possesses the power of moving 0".25 either to the east or west at any time of the day and night without giving any indication of the fact.

Readings of a Collimator Cross.

The experiments on the suspected change of reading of a collimator cross were carried out by Mr. Eccles. The telescope was first placed in position and in intersecting the cross of the northern with the vertical wire of the southern collimator, view was obtained through the aperture in the cube; with these conditions holding, four readings were taken and recorded. The telescope was then removed and four readings obtained with uninterrupted vision. This process was repeated four times in each pivot position of both telescopes, and ample data was thus afforded for the required comparison. In spite of the large and constant difference found at Greenwich the only conclusion to be drawn from Mr. Eccles' results is that the north collimator readings are not in any way affected by the interposition of a telescope.

Velocity of Electricity.

The experiments made with the purpose of discovering the time taken by an electric current in traversing the distance from A station to B, and that taken by the same current in returning from B to A are fully described elsewhere in this Report. It will suffice to state here that conjecture No. (2) was found to be directly contradicted by the results, but that the circuit errors of 1885-86 were not sensibly improved by the application to each arc of the newly deduced correction for "electric rate."

Method of Observation.

The first two conjectures being, therefore, proved insufficient to account for the unexplained phenomena, a programme of star observations was accordingly drawn up, so that the confirmation or confutation of the remaining three was reasonably considered to be assured.

From the experimental arc of May 1886 we knew that, though the difference of longitude between the two stations at Dehra Dún was actually 0".000, yet by observation it was 0".180. The present observations had now to decide whether that erroneous (*i.e.*, observed) value was due to inconstancy of personal equation, to unknown telescopic errors, or to some physical cause; the programme was, therefore, made to contain certain judicious interchanges, between the two stations, of telescopes and observers, by which means a localisation of the cause of error would, it was thought, be probably much facilitated. If the *observers* could change both their stations and telescopes without any effect on the results being exhibited, the theory of variable personality would have to be abandoned: if on the other hand the *telescopes* were interchanged between the two stations and no difference of result ensued, the absence of instrumental defects would be established, if finally it was found that *whatever* arrangement of telescopes and observers was adopted, the value of ΔL *never* varied, there would remain but the one conclusion that for some unknown reason and in spite of meridional identity, stars do not apparently transit simultaneously at the two stations.

The work was divided into four arcs, to each arc were devoted four nights, and on each night 40 stars were observed. With two telescopes four combinations of pivot posi-

tions are possible, and we so arranged that on no two nights of any one arc, the same combination should prevail. Of the 40 stars observed nightly, 32 were taken for the determination of the difference of longitude, and the remaining 8 for personal equation.

During the first arc Mr. Eccles observed at the northern station with telescope No. 2, and I at the southern with telescope No 1. We then changed stations leaving telescopes standing: between the 2nd and 3rd arcs we moved back to our original stations, this time taking our telescopes with us; and between the 3rd and 4th we again changed over, leaving as in the first instance all equipment behind.

Results.

The results of the observations taken on the first night of the first arc are unfortunately so discrepant and erratic and moreover so clearly indicate want of skill on the part of the observers, that I have considered it necessary to reject that night's work *in toto* and consequently the final value of ΔL as given by the first arc, being derived from the results of three nights' work only, is not entitled theoretically to the same weight as are the values of the other arcs.

The observations of the last 15 nights, though of no high order of merit, would easily bear comparison with those taken on the arcs of 1885-86. I give this as my deliberate opinion, after having closely examined the two side by side, though their relative value, important as it is to establish, does not in the absence of a recognised standard of excellence admit of mathematical demonstration.

The results of the observations were as follows :—

Arc.	Observer and Telescope.		Difference of Longitude.
	Northern Station.	Southern Station.	
No. 1.	Eccles with Telescope No. 2.	Burrard with Telescope No. 1.	$+0^s{\cdot}048$
	Interchange of observers only.		
No. 2.	Burrard with Telescope No. 2.	Eccles with Telescope No. 1.	$+0^s{\cdot}051$
	Interchange of both Telescopes and Observers.		
No 3.	Eccles with Telescope No. 1.	Burrard with Telescope No. 2.	$+0^s{\cdot}092$
	Interchange of observers only.		
No. 4.	Burrard with Telescope No. 1.	Eccles with Telescope No. 2.	$+0^s{\cdot}075$

Variability of personal equation.

Between the 1st and 2nd arcs as also between the 3rd and 4th the observers changed stations leaving telescopes standing and other conditions in *statu quo*. The effect of the change was in the first instance to *increase* the value of ΔL by $0^s{\cdot}003$, and in the second to *decrease* it by $0^s{\cdot}017$, the mean difference caused being $0^s{\cdot}007$. Now as the circuit errors amount to three-tenths of a second, it is useless to pay any regard to such quantities as $0^s{\cdot}007$, and if it were not for other considerations we might by the light of this result at once discard all theories based on the unsteadiness of personal equation. There are however two facts directly bearing on this question and which cannot be overlooked: one is that in December 1885, when the first interchange of observers was carried out, the result with Strahan at Agra and Heaviside at Amritsar differed from the result with Heaviside at Agra and Strahan at Amritsar by no less than $0^s{\cdot}081$; and the other is, that although the values of all the four arcs are in remarkable accordance, yet the nightly values of ΔL from which these final means are derived frequently differ from the latter by $0^s{\cdot}15$. These two facts, though in nowise tending to establish mutability of personal equation, suffice to raise one's suspicion that the quantity $0^s{\cdot}007$ must be fortuitous and due to cancelment of errors; and in spite of all the precautions taken in drawing up the programme if another distinct source of information had not been available, the question of variable personality might still have remained unsolved.

We had always during the Dehra Dún experiments made a practice of observing 40 stars *per* night instead of the customary 32, the nightly number on regular longitude work: the additional 8 were set apart for the determination of personal equation, a separate value of which therefore exists for every date on which observations were taken. We are thus able to make a direct comparison between the simultaneous variations of personal equation and difference of longitude and thence decide whether the latter is a function of the former.

Table I* has been constructed for the purpose of illustrating this comparison: the

* Table I has been incorporated in the graphical illustration facing page 61 in Part II, where it appears as Diagram No. 1.

chain-dotted line indicates both the true value of ΔL and the mean adopted value of Personal Equation: the thick curve shows the nightly variations of ΔL, and the thin curve those of personal equation: the latter has been so drawn that it would become, if nightly values of personal equation were employed in the Reductions instead of a General Mean, the Zero line of ΔL, and the nightly value of Difference of Longitude under those conditions, would always be the distance between the two curves.

Although a slight mutual attraction between the two curves is undeniably detectable, yet the aberrations of the thin are confined to such insignificant limits when compared to those of the thick, that any attempt to prove the latter to be due to the former cannot but fail. The question as to the possibility of large and sudden changes occurring in the absolute personal equation of any observer has, in my opinion, been conclusively answered in the negative, and no theory based on personal peculiarities can well be advanced again to account for the existence of the circuit errors.

Unknown physical influences.

There is a decided tendency, whatever arrangement of observers and telescopes be adopted, for the value of ΔL to be positive, in other words for the north station to be shewn west of the south. Every possible combination between the stations, telescopes, and observers was made during these experiments, and a positive value was the invariable outcome. The experimental arc of May 1886 coincided in its arrangement of telescopes and observers, with the single exception that Major Strahan was observing instead of Mr. Eccles, with the first arc of this season, and its result was $+0^s.180$.

The thick curve in Table I shews such a marked bias for the positive side of the zero line, that I cannot but believe in the existence of some unknown physical influence. I have made several attempts to classify the various sources of error *without* including natural phenomena among them. A classification which has any claim to credit must contain sufficient data to enable the result of every single observation, however wild, to be satisfactorily explained, and I have no hesitation in saying that it is absolutely impossible by any system of errors to account for all the discrepancies in our work, *unless* we admit the presence of some secret physical force. Hereafter in this report each arc is shown to be affected by a positive error of $0^s.014$ owing to the unequal resistances offered to currents by the two chronographs, and as the mean value of the 4 arcs is $+0^s.066 \pm .007$, it may be assumed that the difference $(0.066 - 0.014 = +0^s.052)$ is a fairly accurate estimate of the constant error attributable to extraneous sources. It is worthy of remark that a natural phenomenon, if its effects remain invariable, though it produces an error in every arc, does not exercise any pernicious influence on the circuits. The experimental arc of 1886 rather goes to prove that the phenomenon discussed above is by no means an unchanging agent, and that consequently the error generated is a function both of the locality and season, in which the observations were taken.

Instrumental errors.

The presence of a pivot error in either telescope has been emphatically denied by the results of these observations; a small telescopic residual, independent of pivot position, does however exist: whether entirely confined to one of the telescopes or partially due to both, we have no means of deciding. All we know is that the interchange of telescopes had the effect of increasing the mean value of ΔL by $0^s.033$. I deduce from it the axiom that with telescope No. 1 at the northern station the arc will be $0^s.017$ too large and with telescope No. 2 the same amount too small.

Instrumental defects have been proved to be the main source of error; there is no clue as to where they exist, nor as to whether they are present in both telescopes or only in one. The maximum error in a single value of ΔL, that can arise from this cause is $0^s.175$ from which we may assume that $0^s.088$ is the maximum error in the time of transit of a star, that can arise from telescopic defects. It seldom happens that these extreme limits are reached in either telescope, and still more seldom that both telescopes exert their full powers of harm at one and the same time, but unfortunately the defects are so constituted, that the generated errors cannot be wholly classed as "accidental" in the usual acceptation of the term, and on this account their final effect may be unduly large. The telescopic errors are peculiar in that they remain constant throughout any one night, and affect every star on that night to an almost identical degree. It is a rare occurrence for two stars observed on one night to give results differing by $0^s.15$, whilst the mean results of two whole consecutive nights frequently disagree by $0^s.30$, occasionally by $0^s.40$, and once on the Agra-Mooltán arc by $0^s.52$. The telescopic errors however possess the property of vanishing, if observations are multiplied, and are therefore to a certain degree related to the "accidental" family; suppose for example on these experiments we take the value of ΔL to be equal to (telescope No. 1—telescope No. 2) throughout, in lieu of to (northern station—southern station), we then get a final result of $+0^s.017$, whether the "station" correction of $+0^s.052$ is applied or not, and it would be difficult to improve on this. I think it a fairly satisfactory proof that the instrumental errors, peculiar as they are, do cancel on the multiplication of observations. The increase in number should however be made not by observing more stars *per* night but by devoting more nights to each arc: difference of longitude has hitherto been determined by 180 observations, distributed equally over six nights; a better result would be indubitably obtained if 15 stars were observed on twelve nights, though the total number of observations would remain the same; and I feel pretty convinced that if 9 stars were observed on twenty consecutive nights for the determination of every arc, we should never hear of circuit errors again.

Classification of errors.

The several sources from which the circuit errors have been shown by the results of the Dehra Dún experiments to *most probably* proceed, are classified in the following table:—

Class.	Source.	Maximum possible error.	Remarks.
Telescopic.	(1) Inherent difference between the two telescopes.	0".017	Constant in sign and amount.
	(2) Defects in telescope No. 1 . .	±0".088	Only to be eliminated by increasing the number of nights *per* arc.
	(3) Defects in telescope No. 2 . .	±0".088	Ditto ditto.
Not known.	Physical phenomena	±0".052	Probably due to atmospheric heterogeneity.
Electrical.	(1) Inequality of resistance offered to electric currents by the two chronographs.	0".014	Always present and constant in sign and amount.
	(2) Relay adjustments . . .	±0".010	
	(3) Exceptional resistance offered to currents *locally* by bad connections, weak batteries, &c.	±0".040	This error seldom exceeds 0".020, but attained its maximum value on two, if not three, nights of the Agra-Mooltan arc.

The actual discovery of some particular instrumental defect cannot in reason be expected to ensue from mere star observations, and if the arguments are admitted, by which the several sources of error have in the above table been localized, the object of the experiments will, I consider, have been fully attained.

The Electrical Experiments.

Owing to the peculiar results that obtained on the Agra-Mooltan arc, suspicions were aroused that star-signals might not be recorded by electrical means as instantaneously as had hitherto been supposed. The object of these experiments was to gain information on this subject in general, of which but little or nothing was known, as well as to solve in detail the several questions that had been raised. As a rule, on any arc the results derived from observations with 'east' clock are 0".06 less than those of observations with 'west' clock: the difference is of course equal to the time that the current is retarded in traversing the distance from the east station to the west, and returning again from the west to the east; we have always *assumed* that the retardation of a current travelling from the east station to the west is the same as when returning from west to east, and that if the whole time occupied in both journeys is 0".06, that spent on each is 0".03. This assumption was based on the idea that the retardation was almost wholly due to the line wire traversed, which is necessarily the same in both cases, and not to local connections at all. On the appearance of the circuit errors all arbitrary assumptions were examined, and much doubt thrown on the basis of the electrical hypothesis. The questions mooted may be summed up as follows:—

(1) Is retardation due to length of line wire?
(2) Is it affected by a change in battery-power?
(3) Will an alteration in the relay adjustments affect it?
(4) Are the retardations in the two chronographs, caused by local connections, relays, and pen-coils, sufficiently insignificant to be considered equal?
(5) Would it be possible from electrical phenomena alone for the value of an arc of longitude to be outside the two values as given by the 'east' and 'west' clocks and not between them?

Method of observing.

In carrying out the experiments the following arrangements were made:—the two chronographs were set up in one room and worked throughout under the same conditions as held in a regular arc. They were made in fact to represent the two terminals of an arc, and all connections were as usual. First A chronograph 'sent clock' to B by means of a fine battery and line wire, and then B 'sent clock' to A. The pens, the relays and the sounder were all worked by the customary local batteries. The *raison d'être* of the experiments necessitated however one departure from rule—instead of each observer having a tappet to record signals on his own chronograph, one and the same tappet was made to work a pen of both chronographs simultaneously. This was effected by putting the tappet and a pen of both chronographs all into one circuit, worked by a local battery, so that whenever the circuit was broken by means of the tappet, the instant of its being done was recorded on both chronographs. During ordinary work one stud of the tappet is connected to the commutator board and the other taken direct to earth: in these experiments the

commutator board of A chronograph was connected to one stud of the tappet, whilst the wire attached to the other instead of going direct to earth passed through B chronograph first. For the first half of the experiments the clock worked the A pen and the tappet the B pen of both chronographs, for the second half this arrangement was reversed.

Explanation of appended table of results.

An abstract of the results is given hereafter in tabular form. Column I gives the reference number of the observation as distinguished on the chronograph records: column II shews the number of cells on the line battery, and column III the chronograph that was "sending clock." In column IV are given the relay adjustments: T_A denotes the translating relay of A chronograph, and R_A the receiving relay: T_B and R_B are similarly the translating and receiving relays of B chronograph: the words "to inner extreme" mean that the adjusting screw of the relay was screwed inwards as far as possible without allowing the tongue to stick, and those "to outer extreme," that a contrary motion was imparted, until the tongue was immovable: the position of the name of the relay in the column shews when the re-adjustment took place. Columns V and VI give the readings of the tappet marks, as recorded respectively by the two chronographs: column VII is the difference of these two readings and is the retardation: if the sign is positive, B chronograph has been retarded, if negative, A. Column VIII is the change in retardation.

Assumed basis.

Before discussing the results at all we have to make one assumption: it is that when the tappet breaks its circuit, the signal on each chronograph is recorded simultaneously; in other words, that the retardation of the tappet current is constant throughout its progress. To justify this assumption we have the following facts:—(1) A pen of each chronograph was worked directly by the tappet; (2) with the exception of the pen coils, the whole length of wire was under 15 yards; (3) any retardation due from pen coils is eliminated by pen equation; (4) except the 15 yards of wire and the pen coils no other source of retardation existed.

It is important to note that when a tappet signal as read off from the A record is *earlier* than the same signal read off from the B, it is the A chronograph, and not the B, as might appear at first sight, that has been affected by retardation; the reason is that it is the clock current (traversing relays), and not the tappet current, which has to overcome the resistance: the tappet signals are recorded instantaneously, but those marking seconds from the clock are always late.

Effect of length of wire.

Length of the line wire has been found not to be, as was supposed, the *sole* cause of retardation, but on the contrary to have a wholly inappreciable effect; on a regular arc the line wire is from 500 to 1,000 miles, whilst in these experiments it could never have exceeded 10 yards: the retardations in the two cases are however identical.

Effect of alterations in battery power.

The strength of the line battery was to start with 24 cells; between observations 4926 and 4927, *vide* Abstract of results, it was reduced to 12 cells, and it was subsequently altered to 2, 4, 12, and 24 cells again. We thus have five changes in the strength of the line battery to examine, all other conditions before and after remaining the same. The results point clearly to the following conclusions:—

(1) that with a very weak battery, when difficulty is experienced in working the pens at all, the retardation is greater by 0".02 than with a strong battery;

(2) that when once the battery is sufficiently strong to easily work the pens, no further increase in its strength will diminish the retardation.

As the current that runs from east to west is generated by the east battery, and the returning one by the west, these results are very welcome; if retardation had varied directly with battery weakness, it would have been necessary in order to secure an equality of retardation on the two opposite currents, to have worked with batteries of identical power. It has, however, been proved, that if both observers see their pens to be easily worked by the batteries, difference of strength will not be a source of error, and no trouble need be taken to minimise it.

Effect of re-adjustment of relays.

By referring to column VIII of the table we can see the effect on retardation of altering a relay adjustment. A change from outer to inner extreme *always* increases the value of this quantity, and a change from inner to outer *always* decreases it; the amount of the increase and decrease is generally 0".01, and on only four occasions greater than 0".02. The smallness of these numbers might lead one to doubt their reality, but the remarkable constancy in sign shews them to be absolutely reliable. It may, therefore, be considered established, that relay adjustments exercise an appreciable effect on retardation, but that however little the attention paid to them by the observer they could never cause in any arc an error larger than 0".01.

Absolute values of the retardations in the two chronographs.

We now come to the most important question of all, *viz.*, whether the retardations in the two chronographs are equal. The last paragraph pertained to the *variation* caused by re-adjustment of relays, whilst this has to deal with the *absolute value* of retardation, caused by the relays in their normal adjustment: in the present experiments the resistance of the line wire was *nil*, that of the pen-coils was eliminated by the application of the pen equation, and the retardation in the chronographs was consequently due to the relays alone. The amount of this retardation is given in

column VII of the table where the sign + denotes that B chronograph is behind A, and the sign – that A is behind B. When A 'sends clock,' the current passes through the relays T_A and R_B, to which the retardation of B is therefore due. A 'sent clock' on three different occasions, and 18 values in all are available. The retardation of B chronograph $= T_A + R_B = 0^s{\cdot}013 \pm {\cdot}004$. B 'sent clock' on four occasions and 19 values in all are available; the retardation of A chronograph $= T_B + R_A = 0^s{\cdot}041 \pm {\cdot}004$. The retardations in the two chronographs instead therefore of being equal are under ordinary conditions and with normal adjustments of relays respectively $0^s{\cdot}013$ and $0^s{\cdot}041$. This discrepancy causes an error in every arc of $\frac{{\cdot}041-{\cdot}013}{2} = 0^s{\cdot}014$, the value of ΔL being that amount too large, when B chronograph is at the east station, and the same amount too small when B chronograph is at the west station.

Possible effect of retardation on an arc.

Referring now to question (5) let the true astronomical value of an arc of longitude be $0^m5^s{\cdot}463$, and let A chronograph be at the eastern station. Suppose the electrical conditions to be ordinary, and the relay adjustments normal, then the value of ΔL by observations with east clock will be $0^m5^s{\cdot}463 - 0^s{\cdot}013 = 0^m5^s{\cdot}450$, and the value of the same by observations with west clock will be $0^m5^s{\cdot}463 + 0^s{\cdot}041 = 0^m5^s{\cdot}504$. The resulting value of the arc, being the mean of these two, will equal $0^m5^s{\cdot}477$ or $0^s{\cdot}014$ in excess of the true value. This error will always prevail under ordinary conditions.

We want now to find what the maximum error is that can be possibly caused in an arc by retardation: both on the Agra-Mooltan arc and during these experiments the sign of the retardation when A was 'sending clock' was negative occasionally. Taking the most unfavourable values possible from the table we get $T_A + R_B = -0^s{\cdot}02$, and $T_B + R_A = -0^s{\cdot}09$: then the value of the arc $0^m5^s{\cdot}463$ by observations with east clock will be $0^m5^s{\cdot}483$, and the value by observations with west clock will be $0^m5^s{\cdot}553$: the resulting value obtained is $0^m5^s{\cdot}518$, being $0^m0^s{\cdot}055$ in error, and the true value lies *outside* the east and west results and not between them.

Final conclusions.

The final conclusions to be drawn from these experiments are: (1) that length of line wire has no effect on value of ΔL; (2) that strength of battery has also no effect, *provided* it is sufficiently strong to work the pens with ease; (3) that relay adjustments should be kept the same throughout any one arc and altered as slightly as possible from arc to arc, but however made they cannot cause an error larger than $0^s{\cdot}01$; (4) that every arc contains an error of $0^s{\cdot}014$ due solely to electrical differences between the two chronographs; (5) that an arc under very exceptional conditions, might be affected from the same cause by an error of $0^s{\cdot}055$, but never by a greater.

Abstract of Results of the Experiments on Retardation.

Reference No. of Observation.	Number of cells on line battery.	The sending chronograph.	Re-adjustments in Relays.	Reading by A chronograph, means of 5 signals.	Reading by B chronograph, means of 5 signals.	A—B= Retardation.	Change in Retardation.	Remarks.
I	II	III	IV	V	VI	VII	VIII	IX
	24	B						Pen equation (Q) positive.
4921	,,	,,		0·60	0·65	—·05		
			T_B to outer extreme				·01	
4922	,,	,,	,,	·46	·50	—·04		
			R_A to outer extreme				·01	
4923	,,	,,	,,	·62	·65	—·03		
		A					·05	
4924	,,	,,	,,	·65	·63	+·02		
			R to outer extreme				·01	
4925	,,	,,	,,	·57	·54	+·03		
			T_A to outer extreme				·00	
4926	,,	,,	,,	·40	·37	+·03	·03	
	12							
4927	,,	,,	,,	·40	·40	+·00		
			T_A to inner extreme				·00	
4928	12	A	,,	0·25	0·25	+·00	·07	
			R_B to inner extreme					
4929	,,	,,	,,	·43	·36	+·07	·10	
		B						
4930	,,	,,	,,	·07	·10	—·03	·01	
			T_B to inner extreme					
4931	,,	,,	,,	·34	·38	—·04		

Abstract of Results of the Experiments on Retardation—contd.

Reference No. of Observation.	Number of cells on line battery.	The sending chronograph.	Re-adjustments in Relays.	Reading by A chronograph, means of 5 signals.	Reading by B chronograph, means of 5 signals.	A—B= Retardation.	Change in Retardation.	Remarks.
I	II	III	IV	V	VI	VII	VIII	IX
	12	B	R_A to inner extreme . .				·04	
4932	,,	,,	,,	·50	·58	—·08		
	2						·01	
4933	,,	,,	,,	·07	·16	—·09		
		A					·13	
4934	,,	,,	,,	·42	·38	+·04		
	4						·06	Change from Q + to Q— 2 cells no longer sufficient on line battery.
4935	,,	,,	,,	·26	·28	—·02		
			T_A to outer extreme . .				·00	
4936	,,	,,	,,	·30	·32	—·02		
			R_B to outer extreme . .				·01	
4937	,,	,,	,,	·56	·57	—·01		
		B					·06	
4938	,,	,,	,,	·39	·46	—·07		
			T_B to outer extreme . .				·04	
4940	,,	,,	,,	·15	·18	—·03		
			R_A to outer extreme . .				·01	
4941	,,	,,	,,	·09	·13	—·04		
	12						·02	
4942	,,	,,	,,	·53	·55	—·02		
			R_A to inner extreme . .				·02	
4943	,,	,,	,,	·57	·61	—·04		
			R_A to outer extreme . .				·01	
4944	,,	,,	,,	·64	·69	—·05		
			T_B to inner extreme . .				·04	
4945	,,	,,	,,	·45	·54	—·09		
		A					·09	
4946	,,	,,	,,	·42	·42	+·00		
			R_B to inner extreme . .				·01	
4947	,,	,,	,,	·51	·50	+·01		
			R_B to outer extreme . .				·01	
4948	,,	,,	,,	·46	·46	+·00		
			T_A to inner extreme . .				·02	
4949	,,	,,	,,	·26	·24	+·02		
	24						·00	
4950	,,	,,	,,	·09	·07	+·02		
			R_B to inner extreme . .				·01	
4951	,,	,,	,,	·45	·44	+·01		
			R_B to outer extreme . .				·01	
4952	,,	,,	,,	·18	·16	+·02		
			T_A to outer extreme . .				·01	
4953	,,	,,	,,	·24	·23	+·01		
		B					·06	
4954	,,	,,	,,	·46	·51	—·05		
			T_B to outer extreme . .				·02	
4955	,,	,,	,,	·49	·52	—·03		
			T_B to inner extreme . .				·01	
4956	24	B	,,	·41	·45	—·04		
			R_A to outer extreme . .				·02	
4957	,,	,,	,,	·06	·08	—·02		
			R_A to inner extreme . .				·01	
4958	,,	,,	,,	·55	·58	—·03		

Extract from the Narrative Report of MAJOR J. HILL, *in charge No. 25 Party,—Season 1886-87.*

TIDAL OPERATIONS.

I now describe briefly the working of each observatory, commencing with those at Aden and Kurrachee and following the order of the stations round the coast.

Aden.—The self-registering tide gauge has worked very satisfactorily, no interruptions having occurred in its registrations during the first seven months of the survey year, and only four short and unimportant interruptions since then.

The self-registering aneroid by Adie has worked without a single interruption throughout the year. The self-registering aneroid by Légé has also worked continuously, but while it is merely being kept in reserve its diagram is not renewed.

The self-registering anemometer has only suffered one interruption. On the 16th February one of the cups was broken by the signal halliard of the flag-staff whilst the flags were being hoisted; but the damage was repaired on the following day and the instrument set working again.

On the 4th April the observatory clerk reported that a distinct shock of earthquake was felt at the observatory at 3-50 P.M., and on the 11th April he reported that a second similar shock occurred at 8-15 A.M. The tidal curves however give no indication of any disturbance.

The Aden tidal observatory was not inspected during the year. The last inspection of it was made by me in August 1886.

Kurrachee.—Throughout the Survey year the self-registering tide gauge at this station has worked very satisfactorily, only one interruption worth noticing having taken place. That interruption was caused by the driving clock stopping on the 16th of November and being under repair until the 20th of the same month. It was repaired and cleaned by the harbour works fitter, and has worked very well ever since.

The self-registering aneroid also worked most satisfactorily, and there was no interruption of any importance in its registrations during the year; it was cleaned in November by the harbour works fitter.

The self-registering anemometer has worked well. The harbour works fitter cleaned its clock in January and the rest of the apparatus in April.

I inspected the observatory towards the end of March accompanied by Sub-Surveyor Dhondu Venayek and found the instruments and everything else connected with the observatory clean and in perfect order. The last inspection was made as far back as November 1884; but frequent inspections of this observatory by the officer in charge of the tidal operations or by his tidal assistant are not necessary owing to the admirable arrangements of Mr. Price, the Port Engineer, who continues to watch over the working of the observatory with as great an interest as ever, and who has appointed an overseer to make daily visits to the observatory and to take periodical measurements for determination of zero, &c., and one of the harbour works fitters to do the necessary cleaning and repairing of the instruments.

Bhávnagar.—The registrations of the self-registering tide gauge at Bhávnagar have been satisfactory throughout the year. The cylinder was flushed out every fortnight; on each of these occasions there is necessarily a short break in the registrations, lasting from two to four hours, which is supplied by interpolation when the gauge is re-started. The accidental interruptions were few and unimportant, except one which occurred on the 8th April, when the silvered wire between the pencil and the float broke at 9 P.M. It was renewed at 4 P.M. the following day. This interruption is unimportant in itself; but if the wire were to break again before zero measurements are obtained, the registrations between the two breaks might then become vitiated.

The self-registering aneroid and anemometer have continued to work well, only a few unimportant interruptions having occurred in their registrations through the stoppage of their clocks.

I inspected the observatory during the week embracing the last days of November and the first days of December, accompanied by Sub-Surveyor Dhondu Venayek and the watchmaker of the party, and found the observatory remarkably well constructed and most conveniently adapted to its purposes. Everything was in good order and the clerk understood his duties. Thanks are due to Mr. Proctor Sims, the State Engineer, and his assistants, for the interest they continue to take in the working of the observatory.

The tides at Bhávnagar are remarkable in one respect: the water rises gradually to high-water, when a long pause of about an hour and twenty minutes occurs, after which the water sinks more rapidly than it rose. The top of the tidal curve is very level throughout the pause, and the practical effect of this peculiarity is that the water for about 40 minutes before and after every high-water may be considered to be at the same level as the height of high-water given in the Tide Tables. The tidal observatory stands on the right bank of the Kálubhár river about 4 miles above its mouth, in tidal waters. The river flows eastwards into the gulf, the shores of which extend north and south from the mouth of the river, and the peculiarity of the tides at the observatory would seem to be due to the presence of a long bank situated in the gulf close to the mouth of the river, following the direction of the coast line both to the north and south.

Bombay (*Apollo Bandar*).—There is neither aneroid barometer nor anemometer at this observatory; but the self-registering tide gauge, as usual, worked extremely well, in spite of the fact that some of its parts were nearly worn out and had to be renewed.

I inspected the observatory towards the end of November, when everything was going on satisfactorily. I was accompanied in my inspection by Sub-Surveyor Dhondu Venayek and the watchmaker of the party. The old float band had to be renewed and the bottom of the float had become so thin that I arranged with the Port Trust Engineer for having a new one made as soon as possible. The driving clock had also to be removed and sent to Messrs. Favre Leuba and Co. for repair, and while this was being done the Port Trust Engineer most kindly provided men to assist the observatory clerk in taking registrations every quarter of an hour day and night which were entered by hand on the tidal diagrams, thus securing continuous registrations. After completing these arrangements I went on to Bhávnagar to make the inspection of that observatory. On my return to Bombay early in December, I found the new float ready, so I left Dhondu Venayek to attach it in lieu of the old one and went to Poona for a couple of days to attend to work there. On returning I made my final inspection and left the tide gauge clean and in thoroughly good working order, with the exception of the clock which was still in Messrs. Favre Leuba's hands. Major Baird was at this time acting as Mint Master in Bombay, and a few days after my departure he obliged me by seeing the clock properly attached and the gauge re-started. After the attachment of the clock it required regulating for three days; but on the 21st December it was working accurately, and since then the automatic registrations have been uninterrupted. Warm thanks are due to Mr. Ormiston, the Port Trust Engineer, for his co-operation, without which the tidal registrations while the gauge was under repair would have been very imperfect, and to Major Baird for his assistance.

Mormugáo.—The tide gauge at this observatory worked uninterruptedly throughout the year. The pencil however failed to mark the diagram for a few hours consecutively on three occasions; but as it was possible to interpolate the omissions they have not caused any inconvenience, and the tidal registrations throughout the year may be considered to be very satisfactory.

The self-registering anemometer also worked well. There were only seven short interruptions to its registrations during the year, three of them caused by the stoppage of the driving clock, three by the neglect of the observatory clerk to gear the barrel and one by the direction pointer falling out.

The old self-registering aneroid by Adie modified by Légé has not been working satisfactorily owing to accidents which occurred both before and after the inspection of the observatory and will require thorough examination and probably repair at next inspection. The reserve aneroid by Légé and Co. was thoroughly put in order during the inspection, after which its working was found to be all that could be desired.

The observatory was inspected early in January by Mr. Belcham accompanied by the watchmaker of the party, when all the instruments were thoroughly cleaned and left in good working order. Mr. Good continued his kind supervision of the registrations until last May, since when they have been under the supervision of the Harbour Master.

Cochin.—The tidal registrations were perfect up to the 4th April, when an unexpected accumulation of sand formed near the observatory and embedded the rose of the communication pipe, thus preventing free access of the water in and out of the cylinder and rendering the registrations inaccurate. Captain Winckler, the Port Officer, tried his utmost to remove the sand and had the pipe extended further into the river, but the curves remained inaccurate and imperfect until the 26th May, when the accumulated sand through the action of the water was removed as unexpectedly as it had appeared, and free communication became restored. The curves have been correctly registered ever since without any interruption, and it is to be hoped that no similar interruption will occur again. Captain Winckler stated that in his experience of Cochin, extending over four years, no accumulation of sand which could have interfered with tidal observations had ever occurred before.

The self-registering aneroid barometer worked without any failures until the 19th January, but as the readings were noticed at the inspection to be considerably less than those of the mercurial barometer, the gold wire was renewed, after which the instrument worked well up to the 5th February when the observatory clerk found that the minute-hand of the driving clock would not move; he then unfortunately tampered with the instrument, with the result of damaging it so much that it has failed to work ever since, and arrangements for its repair cannot be made until next inspection. Readings of the standard mercurial barometer have however been taken throughout the year at 7 A.M., 10 A.M., 4 P.M., and 6 P.M. The anemometer registrations have been very good, only six interruptions lasting for a few hours at a time having taken place; they were all caused by the driving clock failing to work.

The observatory was inspected in January by Mr. Belcham, who was accompanied by the watchmaker of the party; and all the instruments were cleaned and left in good working order.

Captain Winckler deserves our thanks for his kind exertions to restore the gauge to working order, and for the care he continues to devote to the observatory.

Colombo.—The registrations of the tidal curves for the year under report were remarkably good. There were no stoppages of the clock nor failures from imperfect com-

munication such as occurred last year through the pipe not having then been periodically cleaned. One short break, however, occurred on the 29th June, when the silvered wire between the pencil and float broke, but it was speedily renewed by the observatory clerk. The accident is similar to that which occurred at Bhávnagar on the 8th April and may prove an unfortunate one should the wire break again before there is an opportunity of taking zero measurements.

The anemometer and barometer readings at this port are supplied by the office of the Surveyor-General of Ceylon.

The observatory was inspected by Mr. Belcham in February when the tide gauge was cleaned in all its parts by the watchmaker of the party who accompanied him. The spare pendulum tide gauge clock which was left at the observatory in 1885 was also cleaned, and Mr. Belcham suggested to the Master Attendant that it would be as well if it were set up in his office and kept going instead of being allowed to remain packed up in the observatory.

Thanks are due to Captain Donnan, the Master Attendant, for the great interest he takes in supervising the working of the observatory.

Galle.—The tidal registrations at this station continued without a break until the 15th December when the iron float cylinder became so full of holes through corrosion as to be perfectly useless and to require removal; a new one was, however, very quickly prepared by the Master Attendant, considering the means at his disposal, and it was fixed in position on the 17th January. Since this gap of about a month in the tidal registrations only one unimportant stoppage of the clock for about 8 hours has occurred.

The old pattern self-registering aneroid by Adie worked continuously throughout the year; but for a period of about two months preceding the inspection the readings, owing to the spring being rusty, were more than a tenth of an inch greater than those of the standard mercurial barometer. The new pattern self-registering aneroid by Légé & Co. worked without interruption until the 11th January when the pencil marker began to stick against the diagram, thus preventing the barrel from revolving. Both instruments were put in order at the inspection and have since then worked without any failures.

The anemometrical observations were perfect throughout the year.

The observatory was inspected by Mr. Belcham early in February, when all the instruments were found to be very rusty, and the old float band so corroded that a new one had to be substituted for it. The several instruments were thoroughly cleaned and put into good working order by the watchmaker of the party before the end of the inspection.

The kindness of Captain Blyth, the Master Attendant, in so promptly supplying a new cylinder, thus enabling the interrupted observations to be resumed, together with the great interest he has always taken in superintending the working of the observatory, call for warm acknowledgment.

Negapatam.—This observatory stands close to the northern mouth of the Kadavear backwater on piles driven into the sand, and when my last report was submitted there appeared to be evidence of a slight sinking of the structure causing it to lean a little in the direction of the sea. One of the piles on the side next the sea, to which the graduated staff is attached, seemed to have subsided more than the bed-plate by 0·1 foot. This was confirmed by some measurements taken about the same time by the Port Officer, which showed that there was no retardation of the flow of water in and out of the float box which at this observatory is the substitute for a cylinder.

For a couple of months after these measurements were taken the tidal registrations were uninterrupted and the difference between the readings of the pencil of the gauge and of the graduated staff remained constant. But early in November stormy weather set in, and on the 7th December the Port Officer reported that the sand that usually formed at that time of the year to the north of the tidal observatory had extended itself far into the backwater, and, owing to the boisterous weather, especially that which had prevailed for the last three days, it had suddenly formed itself round the observatory and embedded the cylinder to such an extent as to completely stop the working of the gauge. The sand was resisting his strenuous efforts to clear it away, and he therefore applied to me for help. On receipt of the report I sent Mr. Belcham to Negapatam and by the time of his arrival there on the 18th December he found the accumulation had been sufficiently cleared away to enable him to re-start the gauge. The interruption to the registrations lasted for eleven days, but since the gauge was re-started, the Port Officer has gone to great trouble in taking constant precautionary measures to prevent a re-accumulation of sand, and the tidal registrations have been uninterrupted and satisfactory.

The working of the self-registering aneroid and anemometer have been uninterrupted throughout the year.

The inspection of the observatory was made by Mr. Belcham accompanied by the watchmaker of the party in December at the time when he went to re-start the tide gauge. He found the float band of the tide gauge broken, and the silvered wire connecting the pencil and float very much worn; otherwise all the instruments were in good order, the gauge, however, was out of level, and had settled 0·24 feet. A new float band and silvered wire were attached and all the instruments cleaned and left in good working order. A new graduated staff was also fixed to the observatory in a more convenient position than the old one; but it was carried away on the night of the 21st September by cargo boats which came into collision with it, and another one will have to be erected in its place.

Thanks are due to Captain Dennison, the Port Officer, for his kind exertions during the interruption to the observations, and for the attention he bestows on the observatory.

Madras.—For the first time since this observatory was established, the tidal registrations have continued for a whole year without a single interruption.

The clock, as stated in my last annual report, was repaired in August 1886 by Messrs. Orr & Sons, who thought that the vibration of the pier while cargo was being loaded and unloaded might cause the clock to get out of order at any time; but fortunately no accident such as they anticipated has occurred.

The self-registering aneroid worked without failure until the 3rd June when it got out of order and was sent to Messrs. Orr & Sons for repair by the Port Officer. It was set up again on the 9th August since which time the registrations have been continuous. There is no anemometer at this station.

The inspection of the observatory was carried out in February by Mr. Belcham, when the tide gauge clock was found to be clean, but the other parts of the gauge had to be cleaned by the watchmaker of the party. The aneroid barometer was also cleaned at the same time.

Cocanada.—In my last annual report I mentioned that during the six months extending from the commencement of the tidal observations at this station to the date of that report, no interruptions had taken place in the registrations of the tidal curves. The working of the self-registering tide gauge has continued to be equally good up to the present time, and the tidal registrations since their commencement are without a single break.

The self-registering aneroid worked throughout the year with only one day's interruption; but up to the time of the inspection, the curves were almost straight lines and did not show diurnal variations corresponding to those of the mercurial barometer. The instrument was then adjusted and has since worked well.

The self-registering anemometer has worked very well; but at the inspection it was found that the faulty arrangement referred to in my last annual report was not, as I understood, confined to the direction given to the vane. The interior mechanism was found to be so contrived as to reverse on the diagrams all the directions of the wind, except north-west and south-east, the points to which the instrument was originally set, and the completed diagram will have to be corrected accordingly. A new endless screw having an opposite pitch to that of the one supplied by Messrs. Légé & Co., was made by the watchmaker of the party in Poona to bring the vane to its position of rest in the wind with a motion opposite to that in which it originally moved when the fans revolved. This screw was substituted for the old one at the inspection, and the instrument was reset, so that its readings at north and south should be correct. The vane now points to instead of from the quarter the wind blows; but the interior mechanism remains unchanged and now reverses all direction readings, except those of north and south, so that for this observatory it will now be necessary to correct the printed diagrams received from Messrs. Légé & Co., for use with their anemometors by interchanging the letters E and W wherever they occur at the head of the direction columns.

The inspection of the observatory was made in February by Mr. Belcham accompanied by the watchmaker of the party. He found everything in perfect order, thanks to the kind superintendence of Captain Baker, the Port Officer, who continues to take a great interest in all matters connected with the observatory.

Kidderpore.—The self-registering tide gauge at this observatory has worked very well throughout the year. Such few interruptions to its registrations as occurred were all due to the stoppage of the driving clock, and were quite unimportant.

The self-registering aneroid registrations have also been very satisfactory, only two unimportant interruptions to them having occurred before my inspection and none since then.

I mentioned in my last annual report that the self-registering anemometer had to be removed for repair by Lieutenant Petley, R.N., on the 11th September 1886. Its registrations were resumed on the 3rd October; but it became necessary to remove it again on the 23rd March last, as the building on which it stood had to be pulled down in the course of the dockyard alterations, and Lieutenant Petley had it set up at the tidal observatory. There were 19 interruptions to the registrations between these removals, equivalent to about 3 per mensem, a proportion which can hardly be considered satisfactory. Mr. Belcham visited the observatory in May and found that the direction gear of the anemometer had not been adjusted to the new position of the instrument, and that the diagrams for all the days as far back as the 23rd March required a constant correction; he also found the instrument not upright. He adjusted it correctly, and it has since been working well.

I made an inspection of the observatory in January, accompanied by Sub-Surveyor Dhondu Venayek, and found the instruments, with the exception of the anemometer, in a satisfactory condition. They were all cleaned and left in good working order. Bench-mark A had been removed by the workmen during the alterations in the dockyard, but this was not discovered until I made my inspection. I explained to the observatory clerk that if any bench-mark or anything else connected with the observatory was disturbed or injured, he was to report the circumstance at once to Lieutenant Petley.

Mr. Belcham arrived in Calcutta *en route* to Port Blair on the 5th March, and as he had to wait some days for the Port Blair steamer he employed his time in inspecting the Kidderpore observatory. He found all the instruments clean and in good order; the clock

of the anemometer had however stopped several times since my inspection, and the watchmaker who accompanied him examined it carefully but without being able to discover the cause of its irregular working. Mr. Belcham had to go from Port Blair to Burma to establish a new tidal observatory at Akyab. On his return to Calcutta in May he made a second inspection of the Kidderpore observatory, and found the tide gauge and aneroid in perfect order; but the anemometer which had been removed to the tidal observatory since his last inspection had to be adjusted as already mentioned.

It was fortunate that he had this opportunity of revisiting the observatory, for since his last visit the Irrigation bench-mark which was the bench-mark of reference, and bench-mark B, had both been demolished. In order that the observatory might not be without a convenient bench-mark of reference, he laid down a new one on the granite coping of the eastern wall of the main dock towards its northern end, and connected it by levelling with the bed plate of the gauge and with an engraved circle on the same coping which was one of the points of the line of spirit-levels executed in 1882-83.

In consequence of the alterations that are being made in the Kidderpore docks, the observatory will have to be removed during the coming field season to a new site not far from its present one. After the piles of the new observatory have been sunk and the preliminary levels taken, the removal of the observatory ought not to occupy more than about a fortnight. The zero of the gauge in its future position will be identical with its present zero, and if the Port Commissioners can provide men to assist the observatory clerk in taking readings to a graduated staff while the gauge cannot work, there will be no break in the tidal observations.

I have again the pleasure to acknowledge Lieutenant Petley's unvarying interest in the tidal observations. His extensive experience of the Hooghly tides has enabled him to supply valuable information; and in all matters connected with the observatory we have always been able to rely on his ready help.

Hitherto the tidal predictions for Kidderpore during the times of the freshets have not been satisfactory. Major Baird, however, in correspondence with Mr. Roberts, has arranged a new plan for utilizing the available observations which he believes will have the effect of gradually improving the predictions until they become very correct; and it is hoped that a considerable improvement will be noticeable in the predictions contained in the forthcoming tables for 1888.

Chittagong.—The tidal registrations at this station have been excellent, no interruptions of any importance having occurred in the working of the gauge.

The interruptions to the self-registering aneroid and anemometer have been very few and unimportant, and the working of these instruments has been very satisfactory.

I made my inspection in January, accompanied by Sub-Surveyor Dhondu Venayek. The observatory was found in very good order. All the instruments were examined and cleaned and were left working well. Mr. Good, the Port Officer, kindly superintends the working of the observatory in which he takes great interest. Mr. Belcham when returning to Calcutta after establishing the Akyab tidal observatory, touched at Chittagong and while his steamer was in port he took the opportunity to visit the observatory where everything was found in good order.

Akyab.—On the 24th January I selected the site for the tidal observatory at this new station, every facility being afforded me through the kindness of Captain Fenn, the Port Officer, and Mr. Lackersteen, the Executive Engineer. On the following day I went on by steamer to Rangoon, where I arranged with the Secretary to Government in the Public Works Department for the erection of the observatory and the construction of an iron cylinder for it.

The observatory, the instruments for which, as already mentioned, were sent from Amherst, has been erected over the extreme bay at the north-west corner of the T head of the iron pier opposite the Port Office. It is well ventilated, and very neatly and substantially constructed. The cylinder for the float to work in is of wrought iron, 2 feet in internal diameter and 28 feet long; it consists of four lengths of 7 feet each, and is painted both within and without as a protection against rust, the inside being coloured white in order to facilitate the measurements for determination of zero. The bottom of the cylinder is 7 feet below low-water and is closed with a block of iron wood containing numerous perforations for the free ingress and egress of the water. A graduated staff 15 feet long for checking the height of the water in the cylinder is fixed to the north-west pile of the observatory, its zero being the same as that of the tide gauge.

The anemometer and the aneroid and mercurial barometers are all set up in the observatory.

The construction of the observatory was carried out by Mr. M. R. Lackersteen, the Executive Engineer, Arakan Division, who took the greatest interest in its erection; and we are under obligations to him for the speedy and substantial way in which the observatory has been erected; it is one of the best constructed tidal observatories that have yet been established.

Since the tidal registrations at this station were commenced on the 9th May the tide gauge clock stopped eight times owing to the oscillation caused by steamers coming alongside and leaving the pier; but the interruptions, which always occurred at night during the absence of the observatory clerk, never exceeded twelve hours, and the gaps in the registrations can easily be interpolated.

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The self-registering aneroid and anemometer, with the exception of one interruption of about twelve hours to each, have worked continuously since they were set up.

Captain Fenn, the Port Officer, made himself acquainted with the details of the working of the instruments, and supervises the duties carried on by the observatory clerk. He very kindly lent the mercurial barometer in his office for the use of the observatory, as the one belonging to it had been damaged in transit from Amherst.

Mr. Belcham arrived at Akyab on the 8th April, and on the 13th the erection of the building was commenced. During its erection he remained at Akyab watching its progress and giving details for the internal fittings. On the 3rd May the observatory was completed sufficiently to start the trial registrations, and by the 9th the several instruments were at work after being cleaned and adjusted by the watchmaker of the party who accompanied him.

Elephant Point.—On the whole, the tidal registrations at this station may be considered to be very satisfactory. The observatory was for some time in an unsafe condition and part of the apparatus of the tide gauge was almost worn out. Under such circumstances it is matter for congratulation that there were but a few unimportant interruptions to the registrations. Seven of these were caused by the stoppage of the driving clock, two by the entanglement of the float in the box which at this observatory does duty for a float cylinder, and one by the fracture of the silvered wire connecting the pencil and float. The last mentioned accident was fortunately not repeated before the observatory was inspected and measurements taken for determination of zero, nor has it occurred since then. One other interruption occurred early in May when heavy rain came through the roof of the observatory, deluging the apparatus and causing the clock to stop and the pencil to stick. On this occasion the bed plate was found to be slightly out of level, but it was at once relevelled by the observatory clerk.

The auxiliary instruments are set up at the telegraph station which is about a mile-and-a-quarter distant from the tidal observatory, and are looked after by Mr. Duckworth, the Telegraph Master.

The self-registering aneroid worked well until the 23rd May, when the driving clock got out of order, and the barrel ceased to revolve. From that date up to the 28th June readings were taken from the dial and entered in the daily reports, and the following day the instrument was sent to Rangoon for repair. It was returned on the 22nd August, and its readings since then have only once been interrupted.

As stated in my last annual report, I brought away the self-registering anemometer clock to have it repaired by the watchmaker of the party. It was refixed on the 3rd February, at the time of the inspection of the observatory, and has worked since then with only two stoppages. A break of eleven days, however, occurred in April in the registration of the anemometer, due probably to the barrel not having been properly geared to the clock by the lascar whom the Telegraph Master sends aloft to change the diagrams. With the exception of these interruptions the registrations of the instrument have been satisfactory.

Early in February I made an inspection of the observatory, accompanied by Sub-Surveyor Dhondu Venayek. On the first day of my inspection Mr. Reichenbach, the Port Engineer of Rangoon, accompanied me, as I wished to point out to him some alterations and repairs to the observatory which were urgently needed. He was very obliging and arranged to have everything that was necessary carried out without delay. He also promised to visit the observatory occasionally and test the relative levels of the bed-plate and the bench-mark of reference. The tide gauge was found not to require much cleaning and to be working satisfactorily; but the observatory and the clerk's house were both in very bad repair, and the piles of the former required new bracing in order to render the structure safe, the float box also required renewing. At the close of the inspection all the instruments were left thoroughly clean and in good working order.

At the end of March, Mr. Belcham before proceeding to Akyab, took the opportunity of inspecting the Elephant Point observatory. The float was then found so worn that water had penetrated into it, but not in sufficient quantity to alter the zero; the float band also was very much out of repair. The watchmaker who accompanied Mr. Belcham executed the necessary repairs, and all the instruments were left in serviceable condition. After finishing his inspection Mr. Belcham reported that Mr. Reichenbach had taken in hand the repairs to the observatory.

In my last annual report I mentioned that there was an uncertainty regarding the relative level of the bed-plate of the gauge and the bench-mark of reference at the Elephant Point observatory during the months of July and August 1885 which was likely to cause trouble in preparing for measurement the diagrams for those months. I am glad to say that with the kind assistance of Mr. Reichenbach the results of some levelling done by the former Port Engineer in September 1885 were found and given to me, and the contractor who then repaired the observatory informed me that the only movement given to the structure was a slight lateral one which did not involve taking down the gauge, and which could not have altered its level to any appreciable amount. I was therefore at last in a position to decide that the diagrams in question could be prepared for measurement in the usual way, and I am glad to be able to state that they were completed and read off during the present recess.

Rangoon (Latter Street Wharf).—The record of this station has been far from satisfactory throughout the year; there were many interruptions to the tidal registrations. The

daily reports received up to date mention six interruptions through entanglements caused by the float box, eight through the stoppage of the driving clock of the gauge, seven through the float band slipping off the stud wheel, twenty-two through the pencil failing to mark, and two through the breaking of the silvered wire connecting the pencil and float. Of these mishaps the most unfortunate occurred in October 1886. The chain between the float and counterpoise weight had broken and become entangled with the float box on the 17th of that month, and on the evening of the same day the silvered wire connecting the pencil and float broke. On the following day the Port Trust overseer went to the observatory and proceeded to test the motion of the float band, with the result that the counterpoise weight got entangled at the bottom of the float box and the float band broke, and a new one had to be put on. Another unfortunate accident happened on the afternoon of the 28th December, when the float box which had been attached on the 16th June 1886 was carried away by a strong ebb tide, and half of the float chain was torn off and lost, the float band was also injured but not severed. Work was thus stopped until a new float box could be put up. This was done on the 18th January and the registrations were then resumed after having sustained an interruption lasting for three weeks. Had there been a graduated staff at this observatory, its registrations might have been taken at high and low water during the time the tide gauge was disabled; the break in the registrations would then have been less serious and the laborious calculations of the most probable values required for interpolation during the break described in my last annual report, would have been unnecessary. But there was no graduated staff at the observatory, and when I asked for the readings of the tide pole at Brooking Street Wharf, which would have answered my purpose, as its zero corresponds with that of the self-registering tide gauge, I was informed that no register was kept.

There have been only three failures in the self-registering aneroid registrations during the year, due in all instances to the stoppage of the clock. The instrument however appeared to have got out of adjustment when it was removed with the other instruments after the steamship *Zephyr* came into collision with the observatory, as mentioned in my last annual report, for when I made my inspection I found that the diurnal rise and fall were in most instances imperceptible on the diagrams, and that the aneroid and mercurial barometer readings, which agreed at my previous inspection, showed a considerable divergence. The aneroid was adjusted and has since worked well.

I mentioned in my last annual report that I brought away the self-registering anemometer clock for repair. It was refitted to the instrument when I made my inspection and the whole apparatus has worked remarkably well ever since. Its registrations have only once been interrupted through the clock being stopped by a shock given to the pier supporting the building on which the anemometer is placed.

My inspection of the Rangoon observatory, in which I was accompanied by Sub-Surveyor Dhondu Venayek, extended over the last four days of January and the 1st day of February. I found all the instruments tolerably clean and working steadily, with the exception of the anemometer which was not in use. The instruments including the anemometer were all cleaned and adjusted and left working well.

Mr. Belcham arrived on the 21st March in Rangoon from Port Blair *en route* to Akyab, but was detained for some days in Rangoon seeing about the float cylinder which was being made there by Messrs. Bulloch Brothers and Co. for the Akyab tidal observatory and which was not quite ready, when he also carried out other arrangements connected with the erection of that observatory. At the same time he employed himself very usefully in inspecting the Elephant Point and Rangoon tidal observatories. He found the instruments in the Rangoon observatory as I had left them in February, except that it had been necessary to renew the silvered wire of the gauge between the pencil and float on the 15th March. It broke then for the second time during the year; but as Mr. Belcham was fortunately present to take measurements for the determination of zero before another break occurred, the accident became unimportant. The watchmaker who accompanied Mr. Belcham cleaned the instruments, and substituted a new gold wire in the aneroid for the old wire which required renewal.

Mr. Reichenbach, who succeeded Mr. Jennings as Port Engineer at Rangoon, exercises supervision over the tidal observatories at Rangoon and Elephant Point. I explained to him what was required at both stations, and he very kindly promised to have everything done according to my instructions. Among other necessary improvements he has set up a graduated staff at the Rangoon observatory set to the same zero as the tide gauge, and I hope that before that observatory is again inspected an iron float cylinder to replace the float box may be ready for erection. Mr. Reichenbach also interested himself in my arrangements for establishing a standard bench-mark for Rangoon, which will be mentioned in their place. Mr. Darlington, the Vice-Chairman, Port Commissioners, was very kind in affording me every facility for making my inspections. He also took much interest in choosing a good site for the standard bench-mark, and as a block of stone suitable for it could not be obtained at Rangoon, he authorised me to order one in Bombay. I owe my thanks to both these gentlemen for their kind co-operation.

Port Blair.—The tidal registrations at this island station have not been as good as they might have been had more care been bestowed on their supervision. Actual breaks in them were not many. Half a dozen unimportant breaks were occasioned by the stopping of the driving clock of the tide gauge, and there was a break of five days' duration in May while a new cylinder was being put up in place of the cylinder that had been in use

for about a year-and-a-half and which had worn or been eaten into holes in that time. Interruptions so occasioned were perhaps unavoidable; but in July a series of short interruptions due to the entanglement of the float twice or three times daily was allowed to continue for a week before the cause of the interruptions was removed; and during July and August no notice was taken of a marked discrepancy between the readings of the pencil of the gauge and the graduated staff, clearly indicating a retardation of the flow of water in and out of the cylinder through the obstruction of the inlet holes.

The daily reports sent to me, in which the comparisons between the readings of the gauge and graduated staff are entered, are signed by the Port Officer; but the discrepancy in question, which on the 22nd July actually amounted to one foot, does not appear to have attracted his attention. I wrote to him requesting that free communication might be restored; and the cylinder was accordingly cleaned, with the result that the pencil and staff readings became accordant again.

Nothing else requires notice, except that a slight shock of earthquake was reported to have been felt at the observatory at 2-50 P.M. on the 28th December; but it caused no disturbance in the tidal curve.

The self-registering aneroid and anemometer have worked without a single interruption throughout the year.

The observatory was inspected in March by Mr. Belcham who was accompanied by the watchmaker of the party. Considering that the instruments had not been cleaned since the last inspection, which was made more than two years previously, they were all in very fair order. He found, however, that the observatory clerk had made certain wrong entries in his daily reports. On the 29th November he had reported that the float band had merely been off the stud wheel for a few hours when in point of fact it had broken, and from that date onwards he had been entering identical readings of the float band and pencil instead of the true readings, which Mr. Belcham found to differ by about two inches. Mr. Belcham brought the matter to the notice of the Port Officer who promised to check the readings periodically and compare them with the readings of a graduated staff which Mr. Belcham was then erecting for the purpose of bringing to notice any obstruction of the inlet holes of the cylinder of the gauge sufficient to cause a difference between the level of the water within and without the cylinder; but the Port Officer appears to have let this obligation slip from his memory, and it is to be hoped he will exercise a stricter supervision over the observatory in the future. During the inspection the instruments were thoroughly cleaned and a new float band was fitted to the gauge, and when Mr. Belcham left Port Blair all the instruments were in good order and working well.

The accident which is likely to give most trouble is that which occurred at the Rangoon tidal observatory in October 1886, for it may possibly invalidate the tidal registrations extending back to the preceding July. A breakage of the silvered wire connecting the pencil and float of a tide gauge, followed by another before measurements for determination of zero are obtained, causes the values of the height of the water registered between the breaks to be less precise than they would otherwise have been. The daily records of the reading of the pencil and float band, made by the observatory clerk, are, as a rule, sufficiently accurate to enable the heights to be calculated nearly enough for our purpose; but that they are not invariably so is clear from what is mentioned above as having happened at Port Blair. A breakage of the float band occurring either at the time of the first or second breakage of the silvered wire complicates matters, and when it occurs at both times, as was the case at Rangoon, great doubt is thrown on the intervening height registrations. They may have to be rejected altogether, in which case very laborious calculations for filling the blank in the observations have to be made. Some of the new tide gauges are fitted with chains less liable to break than the silvered wires which in the older gauges connect the pencil and float: these chains should be substituted for the wires as occasion offers, and I have recently indented for a sufficient supply to enable them to be introduced at all the tidal observatories.

Bench-Marks.

The bench-mark at Rangoon which was built with the intention that it should be the standard bench-mark for that city, although altered as mentioned in my last annual report, seemed to me when I made my last inspection of it to be hardly worthy, either as regards its site or construction, of being the standard for so important a city as Rangoon. Mr. Darlington agreed with me and interested himself in the selection of a good site for a standard bench-mark, and authorized me to order the bench-mark stone in Bombay. I accordingly applied to Khan Bahadur Muncherjee Cowasjee Murzban, the Presidency Executive Engineer of Bombay, under whose superintendence the Bombay standard bench-mark had been erected, and after the sanction of the Bombay Government had been obtained he most kindly undertook to have a somewhat similar stone prepared for Rangoon. The stone which was despatched to Rangoon last month is a carefully dressed solid block weighing between 2 and 3 tons and measuring 3 feet by 3 feet by 3 feet 8 inches. It will be embedded 8 inches in a masonry plinth, the portion visible above the masonry being a 3 feet cube. Its top surface will be the plane of reference, and in each of its four vertical faces a space 1½ feet square and 1½ inches deep has been sunk to receive

an inscribed metal plate, to be prepared in Rangoon. It will be erected by the Rangoon Port Engineer within the grassy enclosure near the flagstaff, opposite the Port Commissioners' office, and will be connected by double levelling with the tidal observatory at Latter Street Wharf. The bench-mark originally intended for a standard bench-mark will now become the bench-mark of reference for the tidal observatory.

During the year under report a pair of test bench-marks were laid down in connection with each of the tidal stations of Mormugáo, Kárwár, and Cochin. Five pairs had been laid down when my last annual report was written; so there are eight pairs of test bench-marks in existence at the present time.

One embedded and one inscribed bench-mark were laid down at the new tidal station of Akyab and connected with the observatory and with Colonel Heaviside's Longitude station, and in addition to them 44 embedded bench-marks, including the 6 test bench-marks mentioned in the preceding paragraph, 373 inscribed or minor bench-marks, and 1 Marine Survey bench-mark at Vipeen Island, Cochin, were connected in the course of last season's levelling operations. The bench-marks at the tidal stations were found undisturbed and in satisfactory condition, with the following exceptions:

At Kidderpore all the bench-marks in connection with the tidal observatory were removed in the course of the dockyard alterations; but a new bench-mark was laid down and connected with the bed-plate of the gauge as already mentioned.

At Rangoon bench-mark B was destroyed, and although bench-marks A and C were found intact; their positions render them very liable to damage. The bench-mark of reference however previously mentioned is so solidly built and its surface is so well protected, that no inconvenience would be felt if A and C were to disappear.

At Port Blair bench-mark C has been quite obliterated by the action of the sea.

At Kárwár bench-mark No. 99, entered at page 105 of Pamphlet of Spirit-levelled Heights No. 1, Madras Presidency, seasons 1869—85, was found to have sunk.

At Bhávnagar the bench-mark of reference is not of a sufficiently permanent kind. I therefore requested the Assistant to the State Engineer to have a proper one ready for connection at the next inspection of the observatory.

In my last annual report I mentioned that a bench-mark had been laid down at Tuticorin as a substitute for bench-mark No. 2 of the Pamphlet of Spirit-levelled Heights No. 1, Southern India. In June the Port Officer requested sanction to remove the latter as it interfered greatly with the traffic; and in reply I informed him that if he found it absolutely necessary to remove it, he might do so.

At Poona, bench-marks Nos. 115 and $\frac{1}{116}$ entered at page 14 of Pamphlet of Spirit-levelled Heights Nos. 2 and 3, Bombay Presidency, seasons 1877—80, revised edition, have been disturbed since their heights were originally determined. I have therefore arranged for obtaining new values of their heights, which, with the new value of bench-mark No. 99 at Kárwár, will shortly be issued in *addendum* slips for insertion in the Pamphlets to which they respectively refer.

Levelling Operations.

The operations of the last field season comprised the following lines of double levelling:—

Section I.—From Tuticorin to Madura.
„ II.—From Madura, *viâ* Trichinopoly, to Tanjore to join the line executed in 1885-86.
„ III.—From Trichinopoly to Erode, to join the line executed in 1884-85.
„ IV.—From Shoranúr to Cochin Tidal Station.
„ V.—From Kárwár Tidal Station to Mormugáo Tidal Station.
„ VI.—From Agoada Fort Jetty, where mean sea-level had to be determined independently, to Agoada Station.

In the sanctioned programme for the season's operations a connection was directed to be made with as many stations of the triangulation as fell within convenient reach of the operations, and subsequent instructions regarding the stations of the Great Arc Series directed that only such few of them as were most easily accessible and within very convenient reach of the line of levelling should be connected; three or four stations at some distance apart being amply sufficient for the adjustment of the trigonometrical heights. Permanent bench-marks, known as test bench-marks, had also to be established in connection with the tidal observatories visited in the course of the operations where that had not already been done.

The levelling operations were carried out by Mr Corkery. He worked with the rectangular level; and his assistant Sub-Surveyor Narsing Das worked with the cylindrical level. They left Poona for the field on the 4th November and returned on the 1st June, the field season thus lasting nearly seven months. Their out-turn is very good considering the nature of the country levelled over, which in some parts was hilly, in others densely wooded, and in others intersected by creeks. The out-turn amounts to 450 miles of double levelling, in doing which the instruments were set up at 4,041 stations, and in the course of which 418 bench-marks, and 6 Great Trigonometrical Survey stations were connected. This out-turn falls short of the preceding season's by 76 miles in actual

length and by 18 in the number of Great Trigonometrical Survey stations connected; but in other respects it indicates a greater amount of work done. Thus during last field season the number of bench-marks connected was greater by 24 and the number of stations where the instruments were set up was greater by 332 than during the preceding season; and the rises and falls were greater by 6,742 feet. The work apportioned to Mr. Corkery in accordance with the sanctioned programme was all completed most satisfactorily by him and in a shorter time than in the preceding field season, which commenced on the 3rd November 1885 and ended on the 26th June 1886.

The following extracts are taken from the report submitted to me by Mr. Corkery on his last season's work:—

"I started work on the 11th November at Tuticorin. According to the programme of instructions, section I emanated from the new bench-mark embedded in the verandah of the Port Office, and continuing along the railway line, closed on a bench-mark which I had embedded at Madura. In this section 8 embedded bench-marks, and 93 minor bench-marks, inscribed on prominent features, were connected by spirit-levelling. The distance levelled over was 103¾ miles, including 3 miles of branch lines to trigonometrical stations. The two trigonometrical stations connected were Koilpati H. S. of the Ramnad Longitudinal Series, and Kutipárai S. of the Great Arc Series."

"Section II was started from the embedded bench-mark at Madura on the 11th December and proceeding along the railway line *viá* Trichinopoly where a bench-mark was embedded, closed on the 29th January on the embedded bench-mark at Tanjore, which had been laid down in the previous season: a circuit was thus completed from Tanjore to Tuticorin *viá* Ramnad, returning *viá* Madura and Trichinopoly to Tanjore. The height of G. T. S. □ B. M. at Tanjore as determined in 1885-86 was 193·799 feet above mean sea-level: the present determination is 193·985 above the same datum, or a plus error of +0·186 foot. The length of the circuit is rather more than 400 miles, which would give an error of +·00047 foot per mile.

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"I might mention here that a connection has been made between Ramnad G. T. S. □ B. M. and Madura G. T. S. ⊡ B. M. by the Engineer-in-Chief of the Madras Railway Surveys, and that General Walker's rigorous system of double levelling was to have been carried out. A reference to the abovementioned officer in Bangalore for the results might be of use."

"Section III emanated from G. T. S. □ B. M. at Trichinopoly, and closed on G. T. S. ⊡ B. M. at Erode, on the 3rd March: the total distance in this section was 90½ miles including 3½ miles of a branch line to Ettimalai S. This section occupied the party for one month exactly. There were 9 embedded bench-marks, and 79 minor bench-marks connected. The value of Erode G. T. S. ⊡ B. M. as determined this year was 539·891 feet: the value given in the most recently published Pamphlet of Heights, No. 1 Madras Presidency, seasons 1869-85, is 539·530 feet. The error is + 0·281 foot. The total distance along the line of levels from Madras to Erode *viá* Tuticorin is about 700 miles, the error per mile is therefore ·0004 foot."

"Section IV, which started from an embedded bench-mark at Shoranúr, previously laid down by Mr. Belcham, was not commenced till the 9th March. The line of levels on this section ran along the main road through Cochin State territory *viá* Trichúr and Kodungallúr; at first we had a little difficulty with the village authorities, but a *parwána* from the Dewan of Cochin soon set matters right. The distance levelled in this section, including 1¾ miles of branch lines, was 67 miles, and it occupied the party from the 9th March to the 10th April. Four creeks were crossed, each detaining the party, but the one which presented the greatest difficulty was Kodungallúr, three quarters of a mile of levelling having occupied us for three days. Nine embedded bench-marks including two test bench-marks for Cochin tidal station and 55 minor bench-marks were connected. Elamkunnu h. s. of the Ponáni Connection Series was also connected. This section closed on G. T. S. □ B. M. at the bench-mark of reference for Cochin tidal station. Starting with the value of Shoranúr G. T. S. □ B. M. as given in Pamphlet No. 1 Madras Presidency, seasons 1869—85, the closing value of Cochin was 6·444 feet, and its value deduced from Cochin tidal observatory direct is 6·514 feet. The error in levelling is —0·07 foot, or 0·00106 foot per mile. Progress in this section was very slow owing to the densely wooded country which the line of levels traversed, and also to the difficulties the creeks presented."

"Cranganoor, as it is known to Europeans and as it is found spelt in maps, is a mystery to the inhabitants of Cochin: it is undoubtedly the same as Kodungallúr. As the first landing place in India of St. Thomas the Apostle, it is worthy of mention. I know of no part of India which will repay the traveller so well as the little State of Cochin; it stands out distinctly from the rest of India in its peoples, its history, and in numerous other ways, to enter into all of which would be out of place in a brief report like this. The constant and numerous changes occurring in the physical aspect of the low-lying grounds in this State, as in the neighbouring one of Travancore, intersected as both are by numerous tidal rivers, are worthy of note; it is considered within the probabilities that Cochin town, and all that strip of land in Travancore and in Cochin lying to the west of the system of rivers which form the numerous creeks, will one day revert to their old ocean homes. Vipeen island is said to have been submerged till the fourteenth century. At present a distinct change is taking place in the configuration of the country about Kodungallúr creek, the river forcing a new way for itself to the sea. A system of bench-marks spread over this country might lead to conclusions which would enable those concerned to take steps to save an exceedingly rich and fertile strip of country from a watery grave."

"A wait of five days at Cochin, for a steamer, was more than I had reckoned on: we sailed for Kárwár on the 15th April reaching it on the 18th. The same day we started work on Section V, by verifying the numerous bench-marks laid down at Kárwár many years previously. Bench-mark No. 99 of Section Hubli to Kárwár of Spirit-levelled Heights No. 1 Madras Presidency, 1869—85, is the only one that showed an appreciable sinking, the difference between its present and its former value being 0·046 foot. The length of this section was 59¾ miles, including 3 miles of branch lines, and starting from G. T. S. □ B. M. at Kárwár on the 19th April, the section closed on G. T. S. □ B. M. at Mormugáo, on the 20th May. The branch line to Pil H.S. occupied us for three days: a path had to be cut through the dense undergrowth for two-thirds of the distance up the hill. Eight embedded bench-marks, including two test bench-marks for Kárwár tidal station and two for Mormugáo tidal station together with 33 minor bench-marks, were connected by level.

ling. Accepting the value for Kárwár $\frac{\text{G. T. S.}}{\text{B. M.}}$ (11·772 feet) taken from Kárwár Tide Tables for 1887, the closing value for Mormugáo $\frac{\text{G. T. S.}}{\text{B. M}}$ was 12·525 feet; its value determined from direct tidal observations for the three years ending March 1887, is 12·424 feet; the error is +0·101 foot, or +0·0018 foot per mile."

"In this section also progress was very slow, 59¾ miles of levelling occupying us for one month and two days. The total of rises and falls was over 4,000 feet; this entailed the setting up of the instrument at more than twice as many stations as would be necessary on a railway line."

"The season's levelling may be said to have closed at Mormugáo on the 20th May; the connection of Agoada S. with mean sea-level involving work of a different nature."

"The total out-turn of work for the past season amounts to 450¾ miles, as compared with 526 miles for the season 1885-86. The difference in the nature of the country traversed is evidenced by the fact that the instruments were set up at 4,041 stations compared with 3,709 stations in 1885-86, and also from the fact that the total of rises and falls in 1885-86 was only half of what it was in 1886-87."

The method pursued in determining the height of Agoada S. of the South Konkan Meridional Series above Mormugáo mean sea-level was as follows:—

Before going to Agoada Mr. Corkery and Narsing Das set their watches by the tide gauge clock at the Mormugáo tidal observatory in order that their observations at Agoada and the observatory clerk's at Mormugáo might be made simultaneously. Agoada S. was then connected by double levelling with a bench-mark laid down at the Agoada Fort Jetty in a convenient position for observing the difference between its height and that of the tide as shown upon a levelling staff set up in the water. One complete observation consisted in reading the back and forward staff and the height of the water on the latter, and noting the time. Observations were taken at intervals of 5 minutes, beginning about one hour before high-water and continuing for an equal time after high-water, and the duration of actual high-water was sufficient to enable a couple of observations to be taken then, so that a whole set comprised about 26 observations. A similar set of observations was taken before, during and after low water. Observations were not taken at night. Thus two sets, one about high-water and the other about low-water, were taken daily. While these observations were being taken at Agoada the observatory clerk was taking simultaneous observations at the Mormugáo tidal observatory. One complete observation at the observatory consisted in marking the position of the pencil on the tidal diagram, reading the graduated staff, and noting the time. I had not required Mr. Corkery to take more than two days' observations; but as the water was rather rough he took the precaution of extending the observations over an extra day. They were taken on the 22nd, 23rd and 24th May. I wished to obtain the exact times of high and low-water at Agoada to compare with the corresponding times at Mormugáo; but the sea was not smooth enough to enable this to be done in the available time. At this part of the coast the tide ebbs and flows in a direction nearly perpendicular to the coast line; and reference to the Tide Tables for the current year shows that at Kárwár, which lies 50 miles to the south, high-water was expected about 12 minutes sooner and low-water about 14 minutes sooner than at Mormugáo, and that at Bombay, which lies 250 miles to the north, high-water was expected about 29 minutes later and low-water about 39 minutes later than at Mormugáo, during the time of the observations. Agoada is 5 miles north of Mormugáo; so high and low-water occurred probably about 1 minute later at the former than at the latter place during the time of the observations. On this hypothesis, and knowing that the tidal diagram revolves at the rate of one inch per hour, the positions of the pencil marked by the observatory clerk were misplaced in the direction of revolution by the minute space of $\frac{1}{60}$th of an inch. The range of the tide during the observations did not amount to 4 feet, and the change of level of the water during one minute even at ebb or flow could only have amounted to about a tenth of an inch, whilst owing to the observations having been taken during the times of slack water the mean height of the water at Agoada obtained from two sets of observations, one taken about high-water and the other about low-water, became practically the same as the mean obtained from the two corresponding sets at Mormugáo. Thus no corrections for minute differences of time or for difference of range were required. One set of observations at Agoada combined with the synchronous set at Mormugáo gave one value of the height of the Agoada bench-mark above the zero of the tide gauge at Mormugáo. Six such values were obtained—three at high-water and three at low-water, the mean of which gave the final height of the bench-mark above the zero of the gauge. The difference of level between the zero of the gauge and mean sea-level, as determined at Mormugáo by tidal observations during the three years ending 22nd March 1887, was a known quantity by means of which the heights above mean sea-level of the bench-mark and Agoada S. were finally deduced. A comparison of the values obtained from the diagram and graduated staff at the observatory appears to show that the height of Agoada S. now obtained is probably accurate to 0·03 of a foot. The foregoing procedure is similar in principle though different in details to the method referred to in paragraph 235 of the Survey of India General Report for 1881-82, page 56.

Reduction of the Tidal Observations.

During the year under report the amount of work done in connection with the tidal calculations was large, but the labour of the reductions was not increased, as was the case during the preceding year, by troublesome computations consequent on serious breaks in the tidal registrations. The observations at fifteen stations have been reduced, two years' calculations having been made in the case of three of them; so that the total calculations are equivalent to the reduction of eighteen years' observations at one station. The tabulated values of the tidal constants so obtained and discussions of the results will be found at pages xlvi to lxxvi. Two other tables, marked No. 1 and No. 2, giving the results of the tidal registrations at all the closed stations, are also appended.

The present state of the ordinary tidal computations is shown in the following table together with their state at the end of September 1886. The letters A. P. in the table indicate that the actual times and heights of high and low water for 1886 were measured in duplicate from the tidal diagrams and compared with the predicted values contained in the Tide Tables for that year. The actual amount of work done during the year under report can thus be seen. The extra tidal work is not entered in the table. This consisted in preparing a statement about the tides at Bhávnagar for the officer in charge of the Marine Survey of India, and furnishing reports on the Bombay and Burma tidal observations, as before, to the Local Governments.

State of the ordinary reductions of the yearly tidal registrations at the beginning and end of the Survey year 1886-87.

Tidal Observatory.	State at end of September 1886.	State at end of September 1887.
Aden	1884-85. Calculations completed. 1885-86. Diagrams not read off.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Kurrachee	1884-85. Calculations completed. 1885-86. Diagrams completed and all read off, and the hourly readings being copied from the S. series into the other series.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Bhavnagar	Newly started observatory. No diagrams read off yet.	1886. Calculations completed.
Bombay	1885. Diagrams completed, and all read off, and computations completed.	1886. Diagrams not read off. A. P.
Mormugão	1885-86. Diagrams completed, and all read off, and computations completed.	1886-87. Diagrams read off and the hourly readings copied from the S. series into the other series. A. P.
Cochin	Newly started observatory. No diagrams read off yet.	1886-87. Calculations completed.
Colombo	1885-86. Diagrams completed, and all read off, and summations of series ready.	1885-86. Calculations completed. 1886-87. Diagrams read off, the hourly readings copied from the S. series into the other series, and the additions of hourly heights of each series ready. A. P.
Galle	1885-86. Diagrams completed, and all read off, and summations of series ready.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Negapatam	1885-86. Diagrams not yet read off.	1885-86. Calculations completed. 1886-87. Calculations completed. A. P.
Madras	1884-85. Calculations completed. 1885-86. Diagrams not yet read off.	1885-86. Diagrams read off, the hourly readings copied from S. series into the other series, and the additions of hourly heights of each series, and the summations of series ready, 1886-87. Diagrams not read off. A. P.
Cocanada	Newly started observatory. No diagrams read off yet.	1886-87. Calculations completed.
Dublat (closed September 1886).	1884-85. Calculations completed. 1885-86. Diagrams not yet read off.	1885-86. Calculations completed. A. P.

Station.	Year.	A_0 or Height in feet of Mean level of Sea above Zero.	S_1		S_2		S_4		S_6		S_8		M_1		M_2		M_3		M_4		M_6		M_8		O_1		K_1	
			H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K
				°		°		°		°		°		°		°		°		°		°		°		°		°	
Ohta	1874-75	9·630	0·074	249·69	1·222	14·37	0·013	116·37	0·005	20·32	0·002	219·81	0·031	43·00	3·810	342·11	0·030	20·64	0·136	106·94	0·007	269·65	0·011	96·15	0·693	356·61	1·414	53·11
Hanstal	1874-75	16·332	0·170	164·01	1·398	84·31	0·021	61·74	0·007	166·37	0·003	158·63	0·025	77·23	0·854	45·35	0·098	50·09	0·727	329·61	0·005	140·02	0·083	150·47	0·754	24·70	1·495	81·14
Kathiwadar	1881-82	13·872	0·134	200·38	1·207	80·89	0·029	272·78	0·013	41·89	0·002	265·66	0·037	35·46	2·930	53·28	0·020	131·87	0·220	178·11	0·139	137·46	0·002	298·64	0·720	66·40	1·611	63·30
Kárwár	1876-79	5·698	0·067	158·71	0·561	333·49	0·007	114·66	0·002	31·61	0·002	343·61	0·019	70·05	1·774	303·21	0·012	279·66	0·045	88·20	0·001	220·18	0·046	49·72	0·001	46·55		
	1879-80	5·541	0·073	148·37	0·619	338·44	0·007	83·36	0·007	57·53	0·002	298·46	0·017	45·49	1·733	278·44	0·014	285·39	0·059	87·11	0·004	264·13	0·046	49·72	0·001	46·55		
	1880-81	5·564	0·055	156·16	0·631	333·38	0·006	104·37	0·004	82·24	0·000	256·57	0·019	28·37	1·737	300·35	0·018	273·29	0·054	111·48	0·003	277·11	0·044	8·36	0·005	46·72	1·010	44·66
	1881-82	5·515	0·052	164·71	0·616	332·29	0·011	109·53	0·006	51·34	0·002	282·53	0·045	10·24	1·754	300·87	0·022	262·69	0·059	86·33	0·011	283·65	0·060	58·37	0·004	48·30	1·008	44·33
	1882-83	5·492	0·053	167·47	0·623	334·73	0·011	91·84	0·004	39·16	0·004	308·91	0·047	48·45	1·741	300·72	0·020	262·70	0·061	77·26	0·009	287·36	0·060	58·37	0·004	48·30	1·004	44·83
	Means		5·552	0·057	159·13	0·624	334·79	0·010	99·32	0·005	52·32	0·002	304·22	0·033	46·36	1·742	301·74	0·014	273·03	0·055	87·08	0·011	283·67	0·061	108·86	0·007	49·49	1·004	45·39
Beypore	1876-79	5·788	0·021	119·83	0·331	19·36	0·004	139·69	0·004	254·47	0·001	29·36	0·017	143·76	0·907	339·23	0·011	213·31	0·021	45·30	0·000	130·30	0·008	158·69	0·332	38·93	0·704	57·32
	1879-80	5·730	0·028	96·25	0·311	14·30	0·004	94·20	0·004	220·52	0·002	20·37	0·018	111·01	0·904	329·74	0·010	183·64	0·015	33·80	0·004	114·14	0·010	130·03	0·338	38·89	0·693	53·33
	1880-81	5·412	0·063	187·09	0·308	21·78	0·004	152·80	0·003	265·76	0·001	43·00	0·038	192·26	0·895	332·96	0·011	199·61	0·018	53·33	0·003	184·32	0·007	139·68	0·334	38·95	0·683	54·16
	1881-82	5·412	0·063	187·09	0·308	21·78	0·004	144·69	0·006	226·33	0·000	319·40	0·038	192·26	0·895	332·96	0·011	199·61	0·018	53·33	0·003	184·32	0·007	139·68	0·334	38·95	0·737	57·03
	1882-83	5·395	0·035	170·85	0·359	11·58	0·007	147·33	0·010	242·65	0·001	339·44	0·050	90·35	1·001	323·67	0·009	193·30	0·026	31·39	0·012	132·67	0·009	161·87	0·336	35·13	0·737	47·67
	1883-84	5·360	0·048	171·77	0·350	11·32	0·007	128·40	0·003	244·04	0·003	96·91	0·035	67·99	0·999	323·32	0·008	198·97	0·027	29·13	0·009	138·52	0·011	158·34	0·337	35·13	0·737	48·17
	Means		5·583	0·059	173·92	0·333	16·77	0·005	133·74	0·006	246·97	0·001	338·65	0·033	71·94	0·943	328·17	0·021	36·19	0·006	134·38	0·009	148·19	0·344	36·92	0·708	39·67	
Pánhan	1878-79	2·666	0·036	146·13	0·377	90·11	0·005	186·82	0·002	245·36	0·004	248·30	0·013	18·74	0·589	46·55	0·016	170·37	0·030	158·66	0·011	41·30	0·005	294·01	0·114	48·37	0·205	43·66
	1879-80	2·795	0·049	130·89	0·375	91·31	0·001	191·31	0·001	167·31	0·003	254·78	0·010	5·20	0·593	46·73	0·015	168·41	0·026	156·48	0·001	50·29	0·004	247·63	0·113	48·33	0·203	43·68
	1880-81	2·759	0·035	153·89	0·377	91·35	0·004	261·87	0·005	195·46	0·002	257·20	0·011	64·33	0·556	43·89	0·013	164·89	0·023	159·16	0·011	40·24	0·004	302·29	0·116	48·82	0·203	45·17
	1881-82	2·705	0·029	164·73	0·384	94·19	0·003	304·16	0·006	179·65	0·001	153·09	0·010	41·52	0·569	47·31	0·012	177·41	0·024	159·35	0·003	54·25	0·007	312·81	0·115	48·77	0·202	45·90
	Means		2·709	0·036	148·37	0·372	91·39	0·003	261·04	0·004	197·00	0·003	223·86	0·011	34·55	0·583	46·62	0·016	170·26	0·026	158·91	0·011	41·67	0·005	314·43	0·115	48·23	0·204	45·63
Viragpatam	1879-80	4·392	0·028	100·62	0·674	280·15	0·001	339·63	0·001	173·69	0·001	72·00	0·003	335·21	1·532	248·57	0·007	332·20	0·014	320·32	0·005	142·73	0·004	123·70	0·130	329·82	0·331	338·04
	1880-81	4·317	0·027	96·47	0·651	280·00	0·006	3·70	0·001	353·00	0·001	353·00	0·004	347·20	1·479	254·44	0·006	341·42	0·013	338·34	0·005	29·76	0·002	243·13	0·144	330·92	0·366	341·84
	1881-82	4·869	0·033	91·47	0·651	280·00	0·006	3·70	0·001	215·69	0·003	60·52	0·001	198·68	1·459	254·44	0·006	41·42	0·013	338·34	0·005	29·76	0·002	243·13	0·144	330·92	0·366	341·84
	1882-83	4·612	0·030	1·49	0·641	289·50	0·006	39·81	0·003	214·70	0·001	27·62	0·004	347·70	1·432	253·50	0·008	13·89	0·016	338·45	0·005	29·76	0·002	243·13	0·142	329·45	0·355	340·88
	1883-84	4·813	0·037	92·65	0·620	287·46	0·004	66·62	0·001	146·31	0·001	73·56	0·007	351·40	1·464	254·75	0·007	10·16	0·013	20·58	0·004	60·69	0·005	214·77	0·138	330·53	0·352	340·32
	1884-85	4·630	0·044	93·63	0·625	288·28	0·003	47·00	0·001	113·96	0·000	288·44	0·008	288·56	1·462	253·76	0·009	21·36	0·004	20·74	0·005	66·47	0·003	244·00	0·139	332·32	0·354	341·00
	Means		4·629	0·048	86·48	0·660·32	0·005	40·69	0·001	136·71	0·001	53·12	0·002	349·26	1·463	253·67	0·006	344·54	0·013	329·89	0·005	68·33	0·004	153·49	0·139	331·59	0·358	342·11	
False Point	1881-82	7·552	0·006	325·24	1·005	301·55	0·007	331·19	0·003	153·44	0·003	218·93	0·001	60·41	2·447	268·81	0·012	33·67	0·035	224·18	0·006	80·09	0·005	229·19	0·175	335·42	0·468	343·68
	1882-83	7·597	0·004	47·16	1·003	304·26	0·003	338·04	0·003	181·04	0·003	251·26	0·002	82·32	2·431	271·10	0·016	36·77	0·041	227·89	0·005	87·76	0·005	236·70	0·176	335·74	0·467	343·77
	1883-84	7·593	0·006	47·53	0·993	302·09	0·003	313·06	0·003	163·30	0·004	286·54	0·004	280·03	2·367	269·40	0·012	35·98	0·035	223·90	0·004	43·84	0·006	191·97	0·176	334·74	0·413	342·77
	1884-85	7·492	0·006	80·41	1·000	298·22	0·006	306·87	0·004	158·20	0·003	182·16	0·004	296·80	2·351	267·05	0·006	27·09	0·009	233·04	0·004	142·36	0·004	202·68	0·176	334·74	0·413	342·77
	Means		7·559	0·011	37·08	1·000	291·53	0·005	322·09	0·004	163·00	0·004	255·42	0·002	210·39	2·399	269·09	0·014	33·38	0·038	227·25	0·005	88·51	0·005	215·14	0·176	335·16	0·440	343·30
Dublat	1881-82	14·234	0·044	99·12	2·053	330·81	0·015	202·44	0·002	130·47	0·004	113·94	0·006	344·14	4·623	290·10	0·043	131·12	0·101	149·32	0·014	274·98	0·004	315·90	0·161	331·09	0·498	353·38
	1882-83	14·499	0·050	120·34	2·163	330·29	0·011	219·54	0·005	58·25	0·003	110·33	0·006	18·83	4·598	289·63	0·043	134·96	0·089	144·84	0·013	253·88	0·004	315·90	0·161	331·09	0·498	353·38
	1883-84	14·407	0·046	148·78	2·147	328·84	0·017	201·23	0·005	40·24	0·003	88·26	0·007	6·44	4·594	290·19	0·051	158·02	0·081	146·83	0·008	249·69	0·002	279·22	0·160	340·23	0·503	351·66
	1884-85	14·278	0·043	151·77	2·093	325·11	0·016	202·56	0·005	35·33	0·004	84·56	0·006	353·39	4·562	290·68	0·043	153·76	0·088	148·63	0·013	256·68	0·004	307·79	0·159	342·90	0·502	352·08
	Means		14·363	0·047	131·50	2·099	330·26	0·011	257·49	0·010	259·38	0·009	129·89	0·007	29·07	4·669	293·80	0·045	130·53	0·081	139·63	0·007	180·69	0·009	298·43	0·156	333·68	0·463	353·56
Diamond Harbour*	1881-82	14·330	0·046	125·39	2·107	327·73	0·016	223·16	0·003	111·47	0·005	100·37	0·017	332·88	4·608	290·89	0·048	148·95	0·011	221·96	0·010	230·83	0·003	337·69	0·163	339·73	0·494	351·83
	1882-83	8·936	0·083	156·14	2·215	26·06	0·117	328·35	0·013	266·42	0·002	204·70	0·020	8·69	5·175	344·89	0·048	219·54	0·036	236·44	0·016	106·44	0·006	247·24	0·232	344·11	0·469	14·06
	1883-84	9·011	0·088	147·38	2·288	25·14	0·122	323·01	0·013	234·83	0·004	41·36	0·020	10·57	5·179	341·56	0·048	222·47	0·034	245·36	0·014	108·36	0·005	343·16	0·228	342·80	0·462	15·63
	1884-85	8·999	0·093	153·82	2·281	26·15	0·132	330·36	0·015	264·73	0·004	240·64	0·022	12·55	5·167	344·58	0·048	224·58	0·032	249·53	0·016	109·33	0·006	311·81	0·231	340·72	0·462	16·50
	1885-86	8·897	0·092	161·09	2·202	26·49	0·132	328·73	0·013	269·36	0·007	285·56	0·022	20·13	5·135	344·71	0·048	232·14	0·033	249·01	0·141	112·37	0·003	348·78	0·217	330·44	0·468	14·32
	1886-87	8·864	0·101	162·94	2·199	25·56	0·125	326·18	0·006	233·13	0·002	173·05	0·021	277·22	5·134	344·82	0·038	224·73	0·765	249·81	0·144	110·03	0·003	354·04	0·215	328·56	0·355	13·49
	Means		8·937	0·091	153·40	2·231	25·96	0·123	327·31	0·012	254·53	0·004	281·36	0·009	163·11	5·164	344·44	0·036	230·31	0·732	247·37	0·130	107·95	0·005	347·43	0·226	340·18	0·501	14·43
Amherst*	1880-81	13·392	0·426	178·20	2·831	108·69	0·095	148·81	0·022	221·61	0·003	209·23	0·041	191·71	0·230	63·94	0·034	287·00	0·273	60·32	0·026	236·63	0·006	282·25	0·322	32·71	0·668	3·47
	1881-82	13·704	0·743	148·52	2·705	102·32	0·118	150·23	0·024	221·06	0·004	248·16	0·041	191·71	0·230	63·94	0·034	287·00	0·273	51·34	0·026	236·63	0·006	282·25	0·322	32·71	0·668	3·47
	1882-83	13·701	0·698	97·13	2·750	104·30	0·104	116·84	0·003	118·09	0·003	269·33	0·053	320·37	0·383	68·46	0·019	273·03	0·355	41·40	0·039	230·30	0·001	220·09	0·323	351·30	0·744	6·22
	1883-84	13·757	0·714	130·19	2·680	100·39	0·081	168·13	0·028	237·31	0·004	80·34	0·037	339·84	0·383	68·46	0·031	274·63	0·363	41·40	0·039	230·30	0·001	220·09	0·324	351·24	0·740	6·22
	1884-85	13·588	0·737	132·76	2·700	95·11	0·099	160·27	0·020	164·48	0·002	260·09	0·038	0·43	0·383	68·46	0·031	274·63	0·363	37·72	0·042	230·54	0·002	222·19	0·324	351·24	0·740	7·18
	1885-86	13·321	0·731	121·86	2·583	102·09	0·073	107·39	0·020	241·57	0·003	244·36	0·042	28·90	0·415	67·36	0·031	259·81	0·373	52·03	0·031	248·96	0·003	239·89	0·320	349·30	0·736	5·88
	Means		13·694	0·726	133·06	2·708	102·03	0·095	133·84	0·026	232·34	0·003	273·32	0·032	34·86	0·370	67·40	0·024	279·34	0·324	41·99	0·031	231·76	0·003	232·84	0·323	342·74	0·709	5·99
Moulmein*	1881-82	8·453	0·095	145·51	1·400	148·32	0·068	230·06	0·006	177·59	0·002	164·48	0·054	118·32	3·884	111·89	0·043	223·89	0·036	168·90	0·016	200·19	0·034	125·48	0·256	44·11	0·452	29·41
	1882-83	8·659	0·099	154·80	1·344	145·31	0·063	235·18	0·006	187·13	0·004	251·57	0·049	110·26	3·763	112·36	0·032	214·84	0·880	169·62	0·017	198·08	0·030	140·50	0·252	46·17	0·442	30·42
	1883-84	8·658	0·096	142·70	1·341	150·08	0·065	231·29	0·004	185·32	0·002	218·19	0·049	116·42	3·726	114·39	0·026	218·62	0·887	174·13	0·016	200·97	0·044	134·00	0·256	46·56	0·414	31·31
	1884-85	8·737	0·095	150·76	1·349	149·26	0·062	229·80	0·005	161·48	0·003	219·76	0·050	124·32	3·729	113·24	0·020	164·34	0·889	171·08	0·015	192·15	0·040	138·54	0·255	51·38	0·423	41·13
	1885-86	8·714	0·114	149·09	1·364	150·30	0·071	232·67	0·007	246·37	0·003	229·96	0·051	121·57	3·787	113·66	0·019	117·12	0·906	172·76	0·017	208·07	0·043	141·96	0·254	50·24	0·424	41·90
	1886-87	8·588	0·074	154·09	1·364	151·41	0·073	228·02	0·007	222·05	0·000	198·44	0·050	118·33	3·693	113·25	0·028	42·00	0·897	170·05	0·014	218·47	0·038	133·01	0·243	51·05	0·429	40·60
	Means		8·562	0·095	149·49	1·361	149·07	0·068	227·30	0·006	213·38	0·002	212·25	0·050	119·50	3·798	113·57	0·024	158·33	0·886	175·10	0·094	203·82	0·039	129·72	0·259	50·61	0·437	41·51

* These are Riverain Stations at which A_0 is the height of mean level of the water above zero.

Name of Station.	Year of Observation.	Period of int
		From
Viragpatam	1882-83	7th November 1882
False Point	1882-83	2nd October 1882
Dublat	1881-82	8th October 1881
Diamond Harbour	1885-86	10th August 1885
	1881-82	30th May 1881
Moulmein		21st January 1882
	1884-85	6th September 1884

TABLE No. 1.

...ents for each particular tide which have been calculated from the values obtained by Tidal observations each year at the stations where the operations are completed.

K_2		P_1		S_2		Q_1		L_2		N_2		J_1		ν_2		μ_2		M_2		M_1		T_2		$(MS)_4$		$(MN)_6$		$2SM_2$		$(M_2S_2)_4$		$(M_2K_1)_3$		$(MK_1S_2)_4$		Lunar Monthly.		Lunar Fort-nightly.		Luni-solar Fort-nightly.		Solar Annual.		Solar Semi-Annual.		Station.
H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	
0°26	12°-0	0°24	12°-0	0°00	12°-0	0°26	12°-0	0°01	12°-0	0°28	12°-0	0°25	12°-0	0°28	12°-0	*	*	0°56	12°-0	0°26	12°-0	0°00	12°-0	—	—	—	—	—	—	—	—	—	—	—	—	0°066	12°-38	0°030	14°-76	0°032	182°-62	0°002	2°-1	0°001	1°-04	Olds.
0°26	12°-0	0°24	12°-0	0°00	12°-0	0°26	12°-0	0°01	12°-0	0°28	12°-0	0°25	12°-0	0°28	12°-0	*	*	0°56	12°-0	0°26	12°-0	0°00	12°-0	—	—	—	—	—	—	—	—	—	—	—	—	0°066	12°-38	0°030	14°-76	0°032	182°-62	0°002	2°-1	0°001	1°-04	Hesketh.
0°26	12°-0	0°24	12°-0	0°00	12°-0	0°26	12°-0	0°01	12°-0	0°28	12°-0	0°25	12°-0	0°28	12°-0	*	*	0°56	12°-0	0°26	12°-0	0°00	12°-0	—	—	—	—	—	—	—	—	—	—	—	—	0°066	12°-38	0°030	14°-76	0°032	182°-62	0°002	2°-1	0°001	1°-04	Kellswicke.
0°25	12°-58	0°24	12°-96	0°00	12°-0	0°25	12°-96	0°01	12°-96	0°27	12°-96	0°24	12°-96	0°27	12°-96	0°01	12°-96	0°54	12°-96	0°25	12°-96	0°00	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°064	12°-42	0°029	14°-83	0°031	182°-62	0°002	2°-11	0°001	1°-05	Kilrush.
0°25	12°-58	0°24	12°-96	0°00	12°-0	0°25	12°-96	0°01	12°-96	0°27	12°-96	0°24	12°-96	0°27	12°-96	0°01	12°-96	0°54	12°-96	0°25	12°-96	0°00	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°001	12°-96	0°064	12°-42	0°029	14°-83	0°031	182°-62	0°002	2°-11	0°001	1°-05

Table showing the comparison between the Analysed and Equilibrium theoretical values of the coefficients of the various Tides in terms of the Main Lunar Tide M_2 for the Stations at which observations have been completed.

Station.	Year.	Semi-diurnal Tides.									Diurnal Tides.					Over Tides.							Compound Tides.				Long Period Tides.				
		Main Solar.	Lunisolar.	Lunar Elliptic.	Evectional.	Lunar Elliptic variational.	Solar Elliptic.		Variational.	Lunisolar.	Declinational.		Elliptic.		Lunar.	Solar.	Lunar.			Solar.			Tri diurnal.	Quarter diurnal.	Tri diurnal.	Quarter diurnal.	Semi diurnal.	Lunar Monthly.	Lunar Fortnightly Tr.	Lunisolar Fortnightly.	Solar annual.	Solar Semi Annual.
		S_2	K_2	N_2	L_2	ν_2	λ_2	$2N_2$	T_2	R_2	ρ_2	K_1	O_1	P_1	Q_1	J_1	M_1	S_1	M_4	M_4	M_6	M_6	S_4	S_4	S_6	(M_2K_2)	$(MS)_3$	$(M_2K_2)_3$	$(M_2N_2)_3$	$(2SM)_2$	M_m	M_f	MS_f	S_a	S_{sa}
Equilibrium Theoretical values		1·463	·1137	·1194	·0248	·0336	·0167	·0406	·0167	—	·0164	·5864	·4151	·1935	·0880	·0433	·0536	—	·0013	—	—	—	—	—	·0221	·0036	·0080	·0040	—	·0346	·0886	·0067	—	·0040
Okha	1872-73	·320	·086	·204	·058	·042	·019	—	—	—	·053	·572	·361	·202	·098	·013	·003	·048	·036	·008	·003	·002	·001	·000	—	·017	—	·002	·017	·042	·038	—	·038
Hansnl	1872-73	·380	·077	·224	·063	·042	·034	—	—	—	·062	·518	·292	·166	·080	·004	·004	·040	·026	·045	·012	·003	·002	·004	—	·031	—	·000	·018	·045	·005	·004	0·013
Kathiwadar	1872-73	·406	·105	·224	·067	·044	·014	·040	—	—	·056	·542	·242	·147	·057	·029	·015	·047	·027	·047	·027	·010	·002	·004	·001	·024	·054	·004	·023	·000	·018	·040	·017
	1873-74	·388	·102	·241	·054	·043	·013	·031	—	—	·059	·586	·256	·156	·064	·027	·011	·053	·027	·046	·020	·004	·004	·001	·000	·023	·060	·003	·027	·059	·006	·046	·006
Marwar	1874-75	·363	·100	·240	·054	·045	·013	·032	—	—	·060	·573	·263	·158	·077	·045	·010	·043	·034	·046	·020	·004	·004	·001	·000	·023	·060	·003	·027	·059	·006	·046	·006
	1875-76	·363	·100	·240	·054	·045	·013	·032	—	—	·060	·573	·263	·158	·077	·045	·010	·043	·034	·046	·020	·004	·004	·001	·000	·023	·060	·003	·027	·059	·006	·046	·006
	1876-77	·353	·100	·253	·054	·045	·013	·032	—	—	·060	·573	·263	·158	·077	·045	·010	·043	·034	·046	·020	·004	·004	·001	·000	·023	·060	·003	·027	·059	·006	·046	·006
	1877-78	·353	·100	·253	·054	·045	·013	·032	—	—	·060	·573	·263	·158	·077	·045	·010	·043	·034	·046	·020	·004	·004	·001	·000	·023	·060	·003	·027	·059	·006	·046	·006
	Means	·358	·100	·236	·053	·044	·013	·032	—	—	·059	·577	·263	·158	·076	·043	·010	·042	·032	·046	·020	·004	·004	·001	·000	·023	·060	·003	·027	·059	·006	·046	·006
	1878-79	·385	·103	·211	·060	·039	·014	·036	—	—	·066	·726	·322	·203	·096	·059	·019	·063	·052	·051	·029	·004	·004	·001	·000	·028	·062	·004	·034	·064	·007	·056	·007
	1879-80	·341	·087	·209	·052	·040	·012	·031	·048	·013	·060	·703	·311	·196	·093	·057	·018	·061	·050	·049	·028	·004	·004	·001	·000	·027	·060	·004	·033	·062	·007	·054	·007
Beypore	1880-81	·344	·090	·214	·053	·041	·012	·032	·049	·013	·061	·709	·314	·198	·094	·058	·018	·062	·051	·050	·028	·004	·004	·001	·000	·027	·061	·004	·033	·063	·007	·055	·007
	1881-82	·339	·096	·213	·053	·041	·012	·032	·049	·013	·061	·718	·318	·201	·095	·058	·018	·063	·051	·050	·028	·004	·004	·001	·000	·027	·061	·004	·033	·063	·007	·055	·007
	1882-83	·340	·095	·215	·053	·041	·012	·032	·049	·013	·061	·718	·318	·201	·095	·058	·018	·063	·051	·050	·028	·004	·004	·001	·000	·027	·061	·004	·033	·063	·007	·055	·007
	Means	·352	·094	·213	·053	·040	·012	·032	·049	·013	·061	·711	·316	·200	·094	·058	·018	·062	·051	·050	·028	·004	·004	·001	·000	·027	·061	·004	·033	·063	·007	·055	·007
	1878-79	·640	·173	·363	·088	·067	·022	·060	—	—	·097	·804	·355	·216	·142	·074	·022	·087	·074	·075	·046	·008	·008	·002	·000	·045	·097	·007	·054	·097	·010	·084	·010
Pámban	1879-80	·641	·168	·349	·090	·058	·021	·060	·088	·022	·097	·806	·355	·216	·141	·074	·022	·087	·074	·075	·046	·008	·008	·002	·000	·045	·097	·007	·054	·097	·010	·084	·010
	1880-81	·653	·173	·364	·091	·059	·022	·061	·089	·022	·098	·811	·358	·218	·143	·075	·022	·088	·075	·076	·047	·008	·008	·002	·000	·045	·098	·007	·055	·098	·010	·085	·010
	Means	·645	·171	·356	·090	·058	·021	·060	·088	·022	·097	·807	·356	·217	·142	·074	·022	·087	·074	·075	·046	·008	·008	·002	·000	·045	·097	·007	·054	·097	·010	·084	·010
	1878-79	·480	·122	·252	·055	·038	·014	·043	—	—	·066	·548	·240	·146	·073	·047	·015	·058	·046	·035	·021	·005	·005	·001	·000	·030	·065	·004	·022	·065	·007	·057	·007
	1879-80	·471	·118	·245	·050	·040	·013	·042	·064	·017	·065	·540	·240	·145	·071	·046	·014	·059	·045	·035	·021	·005	·005	·001	·000	·030	·065	·004	·022	·065	·007	·057	·007
Vizagapatam	1880-81	·465	·113	·243	·050	·040	·013	·042	·064	·017	·065	·540	·240	·145	·071	·046	·014	·059	·045	·035	·021	·005	·005	·001	·000	·030	·065	·004	·022	·065	·007	·057	·007
	1881-82	·457	·114	·243	·050	·040	·013	·042	·064	·017	·065	·540	·240	·145	·071	·046	·014	·059	·045	·035	·021	·005	·005	·001	·000	·030	·065	·004	·022	·065	·007	·057	·007
	1882-83	·457	·114	·243	·050	·040	·013	·042	·064	·017	·065	·540	·240	·145	·071	·046	·014	·059	·045	·035	·021	·005	·005	·001	·000	·030	·065	·004	·022	·065	·007	·057	·007
	Means	·466	·115	·245	·050	·040	·013	·042	·064	·017	·065	·542	·240	·145	·071	·046	·014	·059	·045	·035	·021	·005	·005	·001	·000	·030	·065	·004	·022	·065	·007	·057	·007
	1878-79	·447	·111	·202	·051	·031	·014	·034	·050	·016	·063	·587	·284	·171	·095	·055	·016	·064	·054	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
Palur Point	1879-80	·447	·119	·210	·050	·033	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	1880-81	·438	·117	·207	·050	·033	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	1881-82	·438	·117	·207	·050	·033	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	Means	·443	·118	·208	·050	·033	·016	·036	·053	·016	·063	·584	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	1878-79	·444	·114	·253	·056	·035	·014	·040	·047	·016	·062	·552	·254	·161	·090	·052	·015	·060	·051	·042	·025	·005	·005	·001	·000	·028	·060	·004	·025	·060	·007	·051	·007
Dublat	1879-80	·443	·110	·253	·056	·035	·014	·040	·047	·016	·062	·552	·254	·161	·090	·052	·015	·060	·051	·042	·025	·005	·005	·001	·000	·028	·060	·004	·025	·060	·007	·051	·007
	1880-81	·443	·110	·253	·056	·035	·014	·040	·047	·016	·062	·552	·254	·161	·090	·052	·015	·060	·051	·042	·025	·005	·005	·001	·000	·028	·060	·004	·025	·060	·007	·051	·007
	1881-82	·443	·110	·253	·056	·035	·014	·040	·047	·016	·062	·552	·254	·161	·090	·052	·015	·060	·051	·042	·025	·005	·005	·001	·000	·028	·060	·004	·025	·060	·007	·051	·007
	Means	·457	·113	·254	·056	·035	·014	·040	·047	·016	·062	·552	·254	·161	·090	·052	·015	·060	·051	·042	·025	·005	·005	·001	·000	·028	·060	·004	·025	·060	·007	·051	·007
	1878-79	·478	·123	·294	·061	·041	·017	—	—	—	·073	·636	·296	·188	·104	·064	·018	·069	·060	·058	·033	·006	·006	·002	·000	·033	·073	·005	·039	·073	·008	·065	·008
Diamond Harbour	1879-80	·477	·120	·274	·061	·041	·017	·043	·062	·018	·073	·636	·296	·188	·104	·064	·018	·069	·060	·058	·033	·006	·006	·002	·000	·033	·073	·005	·039	·073	·008	·065	·008
	1880-81	·477	·121	·274	·061	·041	·017	·043	·062	·018	·073	·636	·296	·188	·104	·064	·018	·069	·060	·058	·033	·006	·006	·002	·000	·033	·073	·005	·039	·073	·008	·065	·008
	1881-82	·477	·121	·274	·061	·041	·017	·043	·062	·018	·073	·636	·296	·188	·104	·064	·018	·069	·060	·058	·033	·006	·006	·002	·000	·033	·073	·005	·039	·073	·008	·065	·008
	Means	·477	·121	·274	·061	·041	·017	·043	·062	·018	·073	·636	·296	·188	·104	·064	·018	·069	·060	·058	·033	·006	·006	·002	·000	·033	·073	·005	·039	·073	·008	·065	·008
	1878-79	·458	·284	·251	·056	·063	·020	·040	·047	·016	·062	·552	·254	·161	·090	·052	·015	·060	·051	·042	·025	·005	·005	·001	·000	·028	·060	·004	·025	·060	·007	·051	·007
	1879-80	·445	·241	·205	·050	·047	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
Andheri	1880-81	·440	·238	·205	·050	·047	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	1881-82	·440	·238	·205	·050	·047	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	1882-83	·440	·238	·205	·050	·047	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	Means	·445	·240	·205	·050	·047	·016	·036	·053	·016	·063	·582	·276	·166	·093	·054	·015	·063	·052	·045	·027	·005	·005	·001	·000	·029	·063	·004	·027	·063	·007	·054	·007
	1878-79	·380	·105	·189	·047	·028	·011	·034	·046	·016	·059	·526	·238	·154	·086	·050	·014	·057	·049	·040	·024	·005	·005	·001	·000	·027	·059	·004	·024	·059	·006	·049	·006
Kurla	1879-80	·378	·104	·189	·047	·028	·011	·034	·046	·016	·059	·526	·238	·154	·086	·050	·014	·057	·049	·040	·024	·005	·005	·001	·000	·027	·059	·004	·024	·059	·006	·049	·006
	1880-81	·378	·104	·189	·047	·028	·011	·034	·046	·016	·059	·526	·238	·154	·086	·050	·014	·057	·049	·040	·024	·005	·005	·001	·000	·027	·059	·004	·024	·059	·006	·049	·006
	1881-82	·378	·104	·189	·047	·028	·011	·034	·046	·016	·059	·526	·238	·154	·086	·050	·014	·057	·049	·040	·024	·005	·005	·001	·000	·027	·059	·004	·024	·059	·006	·049	·006
	Means	·378	·104	·189	·047	·028	·011	·034	·046	·016	·059	·526	·238	·154	·086	·050	·014	·057	·049	·040	·024	·005	·005	·001	·000	·027	·059	·004	·024	·059	·006	·049	·006

Long Period Tides not computed.

State of the ordinary reductions of the yearly tidal registrations, &c.—contd.

Tidal Observatory.	State at end of September 1886.	State at end of September 1887.
Diamond Harbour (closed April 1886).	1884-85. Additions of hourly heights of each series ready. 1885-86. Diagrams not yet read off.	1884-85. Calculations completed. 1885-86. Calculations completed. A. P.
Kidderpore . .	1884-85. Calculations completed. 1885-86. Diagrams completed, and all read off, and the hourly readings copied from the S. series into the other series.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Chittagong . .	Newly started observatory. No diagrams read off yet.	1886-87. Calculations completed.
Akyab . . .	.....	Newly started observatory. No diagrams read off yet.
Elephant Point .	1884. Calculations completed. 1885. Diagrams completed, and all read off, and the hourly readings from the diagrams in hand.	1885. Calculations completed. 1886. Diagrams not read off. A. P.
Rangoon . . .	1884-85. Calculations completed. 1885-86. Diagrams completed, and all read off, and calculations as far as the end of additions of the hourly heights of each series ready.	1885-86. Calculations incomplete. 1886-87. Diagrams not read off. A. P.
Amherst (closed October 1886).	1884-85. Readings of diagrams completed, and the additions of the hourly heights of each series ready. 1885-86. Diagrams not yet read off.	1884-85. Calculations completed. 1885-86. Calculations completed. A. P.
Moulmein (closed April 1886).	1884-85. Readings of diagrams and computations completed. 1885-86. Diagrams not yet read off.	1885-86. Calculations completed. A. P.
Port Blair . .	1884-85. Readings of diagrams and computations completed. 1885-86. Diagrams not yet read off.	1885-86. Diagrams not yet read off. 1886-87. Diagrams not read off. A. P.

The Tide Tables.

In addition to the calculations already mentioned, the usual work was done in connection with the issue of the Tide Tables which will contain the predicted heights and times of every high and low water at twenty-seven tidal stations during the year 1888, and January 1889. The values of the constants have been sent to Mr. Roberts in London ready for use. The mode of calculating them was described in the Annual Report for 1884-85, and the method employed for the riverain tides will be found described in the Tide Tables, in the prefaces to the several riverain stations; the new method of treating the Hooghly observations being also referred to at page xxxv. I should mention that the prefaces, with the exception of that for Chittagong, were prepared by Major Baird.

In my last annual report I gave a table in which was entered the final datum for each of twenty-three tidal observatories, together with the distance of each datum below mean sea-level as then determined. The following new stations may now be added, the distance of the datum below mean sea-level having been determined in each case from the tidal observations of one year only:—

Name of Tidal Observatory.	Datum to which the Heights in the Tide Tables for 1888 are referred.	Datum below mean Sea-level.
		Feet.
Bhávnagar	Indian spring low-water mark	17·178
Cochin	Do. do. do. do.	1·879
Cocanada	Do. do. do. do.	2·610
Chittagong	Do. do. do. do.	6·873

The usual tabular statements showing the percentage and amount of the errors in the predicted times and heights of high and low water for the year 1886, as determined by comparison of the values entered in the Tide Tables for that year with the actual values obtained by measurement from the tidal diagrams, are given in Tables 3 to 7.

No. 3.

Statement showing the Percentage and the amount of the Errors in the Predicted Times of High Water at the various Tidal Stations for the year 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	35	43	12	7	3
Kurrachee	698	24	43	17	12	4
Bombay	705	47	42	6	3	2
Mormugão	702	29	39	14	11	7
Colombo	704	25	39	13	13	10
Galle	662	31	39	10	11	9
Negapatam	681	24	34	13	17	12
Madras	600	19	33	13	16	19
Dublat	494	26	37	17	15	5
Diamond Harbour	194	17	29	19	26	9
Kidderpore	701	22	36	11	17	14
Elephant Point	701	42	40	10	7	1
Rangoon	648	27	48	13	8	4
Amherst	522	44	41	8	6	1
Moulmein	219	19	47	16	14	4
Port Blair	694	27	33	12	22	6

No. 4.

Errors in the Predicted Times of Low Water, 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	30	43	13	10	4
Kurrachee	699	30	42	13	12	3
Bombay	706	36	44	9	9	2
Mormugão	704	27	42	13	12	6
Colombo	706	25	38	13	13	11
Galle	672	35	43	8	8	6
Negapatam	682	19	29	13	17	22
Madras	601	26	34	10	17	13
Dublat	493	24	44	15	13	4
Diamond Harbour	194	11	33	14	24	18
Kidderpore	702	23	37	14	16	10
Elephant Point	703	29	44	14	12	1
Rangoon	649	24	43	15	15	3
Amherst	524	34	43	11	9	3
Moulmein	218	28	42	13	12	5
Port Blair	691	24	31	9	15	21

No. 5.

Statement showing the Percentage and the amount of the Errors in the Predicted Height of High Water at the various Tidal Stations for the year 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	703	90	10	...	...
Kurrachee	698	80	18	2	...
Bombay	705	72	23	4	1
Mormugão	702	84	15	1	...
Colombo	704	89	10	1	...
Galle	662	93	7	...	...
Negapatam	681	85	13	1	1
Madras	600	81	15	3	1
Dublat	494	30	24	21	25
Diamond Harbour	194	10	11	17	62
Kidderpore	701	23	22	14	41
Elephant Point	701	20	20	26	34
Rangoon	648	36	26	15	23
Amherst	522	34	25	20	21
Moulmein	219	20	32	25	23
Port Blair	694	45	53	2	...

No. 6.

Errors in the Predicted Heights of Low Water, 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	94	6	...	...
Kurrachee	699	72	25	3	...
Bombay	706	68	24	6	2
Mormugáo	704	84	16	...	...
Colombo	706	96	4	...	...
Galle	672	96	4	...	...
Negapatam	682	79	18	2	1
Madras	601	74	23	3	...
Dublat	493	41	31	19	9
Diamond Harbour	194	23	27	23	27
Kidderpore	702	26	17	14	43
Elephant Point	703	30	25	20	25
Rangoon	649	18	17	18	47
Amherst	524	36	20	20	24
Moulmein	218	4	14	31	51
Port Blair	691	70	29	1	...

No. 7.

Table of Average Errors in the Predicted Times and Heights of High and Low Water at the several Tidal Stations for the year 1886.

Station.	Mean range at springs, in feet.	Average Errors					
		Of Time, in minutes.		Of Height, in terms of the Range.		Of Height, in inches.	
		H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Aden	6·7	11	12	·025	·025	2	2
Kurrachee	9·7	13	12	·026	·026	3	3
Bombay	14·5	8	10	·017	·023	3	4
Mormugão	7·0	13	13	·036	·036	3	3
Colombo	2·4	15	15	·069	·069	2	2
Galle	2·2	13	12	·076	·076	2	2
Negapatam	2·6	22	19	·096	·096	3	3
Madras	3·5	18	16	·071	·071	3	3
Dublat	14·2	13	13	·047	·035	8	6
Diamond Harbour	15·8	17	19	·074	048	14	9
Kidderpore	11·7	16	15	·114	·135	16	19
Elephant Point	10·2	9	11	·050	·035	11	8
Rangoon	16·4	11	13	·041	·061	8	12
Amherst	20·5	8	10	·033	·033	8	8
Moulmein	12·7	13	12	·059	·085	9	13
Port Blair	6·6	14	18	·063	·038	5	3

From this last table it will be seen that Bombay came first in the order of excellence as regards both its time and height predictions; Aden, Kurrachee and Mormugáo being also very good. The predictions for Madras, Negapatam and the Ceylon stations were not as good as those for the open coast stations elsewhere, nor do the predictions for Port Blair compare so favourably with the others as might have been expected from the position of the station. With regard to the riverain stations, it is interesting to observe the difference between the results obtained at the stations situated at the mouths of rivers and at those situated up-stream, the former, as might be expected, being superior to the latter. Thus the predictions for Amherst were very good, and superior to those for Moulmein; the Elephant Point predictions were good, and superior to those for Rangoon; and the Dublat predictions were good, and superior to those for Diamond Harbour and Kidderpore. The predictions on the whole may be considered to be very satisfactory, the least so being those for Negapatam and Kidderpore.

The predictions for Kidderpore are likely to improve gradually year by year for the reason given at page xxxv, and where there are peculiarities in the tides, as at Bhávnagar and Moulmein, a continued comparison of the actual and predicted times and heights of the tides will doubtless enable improvements to be made by degrees in the predictions. Until the Tide Tables for 1888 are published, there will be no predictions for Bhávnagar to compare with actuals. All that is known at present is that the tidal registrations there have been carried on very satisfactorily since their commencement. At Moulmein, although

the time predictions are good, the predictions for height are not equally satisfactory. The observatory has been removed, but actual values continue to be obtained for comparison with the predictions, as already stated. I do not think that attention has been drawn in preceding reports to a remarkable peculiarity of the Moulmein tides which, strange to say, does not appear to have been noticed until brought to light by our tidal registrations. It is this that at the jetty, where our tidal measurements were taken, the water, although rising higher at spring tides than at neaps, falls lower at neaps than at springs.

I append to this report a copy of a memorandum by Major Baird on certain tidal disturbances at the head of the Bay of Bengal on the 11th March and 9th April 1885. In February last, whilst he was attached to this office, he came across some very peculiar tidal curves of those dates; and as General Strachey, R.E., had asked him about the time of the Krakatoa tidal disturbances to look out for any irregularities on future tidal diagrams indicating disturbances of a like kind and keep him informed, he sent him the memorandum in question and tracings from the tidal curves.

Values of the Tidal Constants, Aden, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or seventh year's observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 5{\cdot}883$ feet.

S_1	H =	0·077	M_6	R =	0·003	Q_1	R =	0·110	T_2	R =	...
	κ = ζ =	162° 20		ζ =	159°·23		ζ =	67°·67		ζ =	...
S_2	H = R =	0·692		H =	0·003		H =	0·136		H =	...
	κ = ζ =	245°·33		κ =	14°·06		κ =	34°·55		κ =	...
S_4	H = R =	0·005	M_8	R =	0·003	L_2	R =	0·039	$(MS)_4$	R =	0·006
	κ = ζ =	323°·62		ζ =	214°·38		ζ =	325°·57		ζ =	221°·47
S_6	H = R =	0·005		H =	0·002		H =	0·034		H =	0·006
	κ = ζ =	220°·86		κ =	20°·82		κ =	196°·90		κ =	173°·08
S_8	H = R =	0·002	O_1	R =	0·539	N_2	R =	0·461	$(2SM)_2$	R =	0·020
	κ = ζ =	334°·98		ζ =	335°·58		ζ =	2°·43		ζ =	60°·69
				H =	0·669		H =	0·444		H =	0·019
				κ =	36°·93		κ =	219°·56		κ =	109°·08
M_1	R =	0·014	K_1	R =	1·153	λ_2	R =	0·035	$2N_2$	R =	0·094
	ζ =	225°·58		ζ =	143°·92		ζ =	115°·22		ζ =	76°·29
	H =	0·015		H =	1·307		H =	0·033		H =	0·091
	κ =	58°·21		κ =	35°·09		κ =	200°·60		κ =	198°·94
M_2	R =	1·633	K_2	R =	0·146	ν_2	R =	0·094	$(M_2N)_4$	R =	0·070
	ζ =	274°·15		ζ =	283°·63		ζ =	181°·92		ζ =	228°·42
	H =	1·573		H =	0·195		H =	0·090		H =	0·065
	κ =	225°·76		κ =	245°·84		κ =	179°·76		κ =	37°·16
M_3	R =	0·022	P_1	R =	0·409	μ_2	R =	0·086	$(M_2K_1)_3$	R =	0·010
	ζ =	118°·21		ζ =	282°·95		ζ =	276°·78		ζ =	293°·04
	H =	0·021		H =	0·409		H =	0·080		H =	0·011
	κ =	225°·63		κ =	31°·64		κ =	180°·00		κ =	135°·73
M_4	R =	0·009	J_1	R =	0·055	R_2	R =	...	$(2M_2K_1)_3$	R =	0·002
	ζ =	75° 62		ζ =	59° 79		ζ =	...		ζ =	309°·81
	H =	0·008		H =	0·067		H =	...		H =	0·003
	κ =	338°·84		κ =	44°·53		κ =	...		κ =	321°·94

Long Period Tides.

	R	ζ	H	κ
Lunar monthly Tide	0·018	266°·80	0·016	1°·28
„ fortnightly „	0·024	5·50	0·038	14·40
Luni-solar „ „	0·014	140·97	0·013	189·36
Solar-annual „	0·448	22·11	0·448	3·41
„ semi-annual „	0·183	181·57	0·183	144·18

The value of the mean level of the sea (A_0) is 5·883 feet above the zero of the gauge, it is the largest value obtained, but is only 0·129 foot greater than the least value, that of 1882-83, since the observations were commenced in 1879.

The main lunar tide (M_2) has a mean amplitude (H) of 1·573 feet and is identical with the mean of the preceding six years' values. The epoch of this tide is 225°·63 and agrees very well with those of preceding years.

The main solar tide (S_2) has an amplitude of 0·692 foot and is very accordant with all the values of the amplitude of this tide at Aden; its epoch too agrees well with previous values.

The amplitude 1·307 feet of the main diurnal tide (K_1) is very accordant with all the values obtained in previous years; its epoch also agrees well with former values, the greatest difference being a little under 4° or 16 minutes in time.

The main solar tide (S_2) is 44 per cent. of the main tide, and this proportion is the same as in former years; theoretically it should be 47 per cent.

The proportion of the luni-solar tide (K_2) to the main tide is 0·124 which is very nearly the same as the theoretical proportion 0·127, and this has always been found to be the case at Aden.

The proportion of the smaller elliptic tide (L_2) is 0·022, and that of the larger elliptic tide (N_2) is 0·282, the theoretical values of these two tides are 0·028 and 0·194 respectively of the main tide; the proportions now obtained are very close to those of previous years.

The larger evectional tide (ν_2) is 0·057 of the main tide, theoretically it should be 0·038, but the values of this tide at Aden have varied considerably and range from 0·03 to 0·10 of the main tide.

The smaller evectional tide (λ_2) is 0·021 of the main tide and is almost identical with last year's value, theoretically it should be 0·007.

The lunar elliptic tide of the second order ($2N_2$) is slightly more than double the theoretical value 0·026, and this proportion has always been obtained.

The variational tide (μ_2) is 0·051 of the main tide, a proportion which is about double the theoretical and agrees well with those hitherto obtained.

The proportions of the diurnal tides to the main tide are as follow:—

		Aden, 1883-86.	Theoretical.
Luni-solar	(K_1)	0·831	0·584
Lunar	(M_1)	·010	·036
Solar declinational	(P_1)	·260	·193
Lunar „	(O_1)	·425	·415
„ elliptic	(J_1)	·043	·033
Solar „	(Q_1)	·086	·080

With the exception of the value of (M_1), which is the smallest yet obtained, the proportions all agree well with former values.

The overtides as usual at this port are insignificant, and the same remark applies to the compound tides; except the quarter diurnal tide ($M_2N)_4$ which is 0·041 of the main tide.

Of the long period tides the lunar monthly tide is 0·010 of the main tide, which agrees with the 1883-84 value; the theoretical proportion is 0·046, and this was only attained in 1880-81, when it was 0·049.

The lunar fortnightly tide is 0·024 of the main tide or three times as great as last year, but fairly accordant with the other five years' values; the theoretical proportion for this tide is 0·086.

The luni-solar fortnightly tide is 0·008 of the main tide, or very nearly the theoretical proportion 0·007, and agrees very well with former values.

The solar-annual tide is 29 per cent. of the main tide, which is about 5 per cent. greater than the mean of the other six years' determinations; its time of maximum is this year the 24th March, or seven days later than last year.

The solar semi-annual tide has the largest proportion to the main tide that has yet been determined, *vis.*, 0·116, the theoretical proportion being 0·040.

Values of the Tidal Constants, Kurrachee, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=7·206 feet.

S_1	H=		M_6	R=	0·059	Q_1	R=	0·101	T_2	R=	...
	κ = ζ =	173°·62		ζ =	335°·18		ζ =	190°·10		ζ =	...
S_2	H= R=	0·950		H=	0·053		H=	0·125		H=	...
	κ = ζ =	322°·33		κ =	198°·57		κ =	52°·58		κ =	...
S_4	H= R=	0·010	M_8	R=	0·006	L_2	R=	0·085	$(MS)_4$	R=	0·036
	κ = ζ =	43°·43		ζ =	88°·85		ζ =	355°·68		ζ =	30°·22
S_6	H= R=	0·006		H=	0·005		H=	0·075		H=	0·035
	κ = ζ =	315°·69		κ =	266°·70		κ =	281°·14		κ =	344°·68
S_8	H= R=	0·001	O_1	R=	0·535	N_2	R=	0·646	$(2SM)_2$	R=	0·021
	κ = ζ =	194°·04		ζ =	40°·12		ζ =	105°·64		ζ =	79°·52
				H=	0·663		H=	0·623		H=	0·020
				κ =	47°·12		κ =	275°·58		κ =	125°·06
M_1	R=	0·038	K_1	R=	1·152	λ_2	R=	0·068	$2N_2$	R=	0·113
	ζ =	291°·72		ζ =	97°·69		ζ =	205°·27		ζ =	212°·11
	H=	0·037		H=	1·305		H=	0·066		H=	0·109
	κ =	133°·57		κ =	46°·30		κ =	240°·50		κ =	237°·53
M_2	R=	2·648	K_2	R=	0·201	ν_2	R=	0·216	$(M_2N)_4$	R=	0·107
	ζ =	338°·04		ζ =	238°·28		ζ =	234°·77		ζ =	266°·69
	H=	2·552		H=	0·269		H=	0·208		H=	0·099
	κ =	292°·50		κ =	315°·67		κ =	288°·47		κ =	31°·09
M_3	R=	0·039	P_1	R=	0·407	μ_2	R=	0·090	$(M_2K_1)_3$	R=	0·022
	ζ =	225°·54		ζ =	354°·13		ζ =	3°·42		ζ =	95°·36
	H=	0·036		H=	0·407		H=	0·084		H=	0·024
	κ =	337°·23		κ =	44°·74		κ =	272°·34		κ =	358°·44
M_4	R=	0·032	J_1	R=	0·033	R_2	R=	...	$(2M_2K_1)_3$	R=	0·018
	ζ =	106°·52		ζ =	314°·13		ζ =	...		ζ =	31°·52
	H=	0·029		H=	0·040		H=	...		H=	0·019
	κ =	15°·44		κ =	46°·12		κ =	...		κ =	351°·83

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·072	216°·40	0·064	0°·93
,, fortnightly ,, ...	0·048	1 ·79	0·076	122 ·25
Luni-solar ,, ,, ...	0·066	290 ·43	0·064	335 ·97
Solar-annual ,, ...	0·224	66 ·54	0·224	105 ·93
,, semi-annual ,, ...	0·109	71 ·68	0·109	150 ·47

The mean level of the sea (A_0) is 7·206 feet above the zero of the gauge; it is very accordant with the two preceding years' values and almost identical with the 1877-78 value.

The mean amplitude (H) of the main lunar tide (M_2) is only 0·006 greater than last year and its epoch is 1½° or 3 minutes in time less.

The values of the amplitude and epoch of the main solar tide (S_2) agree well with all the previous values.

The amplitude 1·305 feet of the main diurnal tide (K_1) is very accordant with the four previous years' values, and its epoch 46°·30 agrees very closely with all the values hitherto obtained.

The proportion of the main solar tide (S_2) to the main lunar tide (M_2) is 0·372, a proportion which agrees well with former values.

The luni-solar tide (K_2) is 0·105 of the main tide, which is somewhat less than the theoretical proportion 0·127.

The larger elliptic tide (N_2) is 24 per cent. of the main tide and similar proportions have always been obtained. Its theoretical proportion is 19 per cent.

The smaller elliptic tide (L_2) is again 3 per cent. of the main tide and agrees with the theoretical proportion.

Of the two evectional tides, the larger (ν_2) has a proportion of 0·082 of the main tide which is more than double the theoretical value; the smaller tide (λ_2) has the same proportion to the main tide as determined last year, *viz.*, 0·026, and is nearly four times as great as the theoretical proportion 0·007.

The lunar elliptic tide of the second order ($2N_2$) is 4 per cent. of the main tide; the values of this tide are found to be in alternate years 4 and 3 per cent., the latter being the theoretical proportion.

The proportion of the variational tide (μ_2) to the main tide is 0·033 which is just double of that determined last year, and is now as much over as it was then under the theoretical value 0·024.

The proportions of the various diurnal tides, with the exception of (J_1) are all very accordant with the last four years' values: the proportion of (J_1) is 0·016 of the main tide, its theoretical proportion being 0·033, last year it was 0·028 of the main tide.

The overtides, both lunar and solar, and the compound tides agree in their proportions to the main tide with all the former values.

Of the long period tides, the lunar monthly tide is 0·025 of the main tide, which is the largest value obtained since 1879-80, but as usual it is less than the theoretical proportion.

The lunar fortnightly tide is this year slightly greater in its proportion to the main tide than in the two previous years, and the values of these three years exceed those obtained for many years previously and are about one-third the theoretical proportion.

The luni-solar fortnightly tide is 0·025 of the main tide, theoretically it should be 0·007; the previous six years' values range from 0·007 to 0·017.

The solar-annual tide is 0·088 of the main tide, the previous six years' values ranged from 0·016 to 0·055 of the main tide.

The solar-semi-annual tide is 0·043 of the main tide, and agrees almost exactly with the theoretical value.

The epoch of the solar annual tide is 106° or 62° later than last year: the epoch of the solar semi-annual tide is 150° or 10° earlier than last year, and the epochs of the other three long-period tides are all as usual very divergent.

Values of the Tidal Constants, Bhavnagar, 1886.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886 or first year's observations at Bhávnagar; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886 observations:—

Short Period Tides.

$A_0 = 22{\cdot}799$ feet.

S_1	H=	R=	0·154	M_6	R=	0·254	Q_1	R=	0·146	T_2	R=	...
	κ = ζ =		179°·93		ζ =	176°·64		ζ =	263°·10		=	...
S_2	H=	R=	3·376		H=	0·228		H=	0·178		H=	...
	κ = ζ =		175°·52		κ =	119°·29		κ =	73°·30		κ=	..
S_4	H=	R=	0·102	M_8	R=	0·018	L_2	R=	0·591	$(MS)_4$	R=	0·661
	κ = ζ =		237°·39		ζ =	135°·83		ζ =	130°·11		=	94°·34
S_6	H=	R=	0·027		H=	0·015		H=	0·589		H=	0·638
	κ = ζ =		307°·75		κ =	179°·37		κ =	165°·60		κ=	195°·23
S_8	H=	R=	0·009	O_1	R=	0·830	N_2	R=	2·361	$(_2SM)_2$	R=	0·045
	κ = ζ =		25°·20		ζ =	167°·33		ζ =	115°·14		ζ =	112°·59
					H=	1·011		H=	2·280		H=	0·044
					κ =	82°·78		κ =	110°·77		κ=	11°·71
M_1	R=		0·090	K_1	R=	2·010	λ_2	R=	0·288	$2N_2$	R=	0·280
	ζ =		83°·19		ζ =	264°·31		ζ =	68°·11		ζ =	213°·58
	H=		0·066		H=	2·257		H=	0·278		H=	0·271
	κ =		201°·08		κ =	91°·69		κ =	142°·14		κ=	103°·95
M_2	R=		10·909	K_2	R=	0·544	ν_2	R=	0·662	$(M_2N)_4$	R=	0·225
	ζ =		33°·98		ζ =	333°·34		ζ =	187°·02		ζ =	356°·08
	H=		10·534		H=	0·715		H=	0·640		H=	0·210
	κ =		134°·87		κ =	168°·73		κ =	134°·76		κ=	92°·59
M_3	R=		0·082	P_1	R=	0·655	μ_2	R=	0·379	$(M_2K_1)_3$	R=	0·175
	ζ =		166°·14		ζ =	284°·31		ζ =	72°·37		ζ =	152°·22
	H=		0·078		H=	0·655		H=	0·353		H=	0·189
	κ =		317°·46		κ =	93°·45		κ =	274°·14		κ=	80°·48
M_4	R=		0·961	J_1	R=	0·100	R_2	R=	...	$(2M_2K_1)_3$	R=	0·117
	ζ =		314°·05		ζ =	248°·70		ζ =	...		ζ =	335°·41
	H=		0·896		H=	0·119		H=	...		H=	0·123
	κ =		155°·81		κ =	179°·39		κ =	...		κ=	349°·80

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·120	260°·84	0·107	6°·09
„ fortnightly „	0·049	309 ·19	0·075	39 ·17
Luni-solar „ „	0·119	129 ·33	0·115	28 ·45
Solar-annual „	0·266	199 ·79	0·266	120 ·66
„ semi-annual „	0·083	323 ·25	0·083	164 ·98

The mean level of the sea (A_0) is 22·799 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow :—

		Bhávnagar, 1886.	Theoretical.
Semi Diurnal Tides.	Main solar . . . . . S_2	0·320	0·465
	Luni-solar . . . . . K_2	·068	·127
	Lunar elliptic . . . . . N_2	·216	·194
	„ „ . . . . . L_2	·056	·028
	Evectional . . . . . ν_2	·061	·038
	„ . . . . . λ_2	·026	·007
	Lunar elliptic of the second order . $2N_2$	·026	·026
	Variational . . . . . μ_2	·034	·024
Diurnal Tides.	Luni-solar . . . . . K_1	·214	·584
	Lunar declinational . . . . O_1	·096	·415
	Solar „ . . . . . P_1	·062	·193
	„ elliptic . . . . . Q_1	·017	·080
	Lunar „ . . . . . J_1	·011	·033
	„ . . . . . M_1	·006	·036
	Solar . . . . . S_1	·015	...
Over Tides.	Lunar . . . . . M_3	·007	·013
	„ . . . . . M_4	·085	...
	„ . . . . . M_6	·022	...
	„ . . . . . M_8	·001	...
	Solar . . . . . S_4	·010	...
	„ . . . . . S_6	·003	...
	„ . . . . . S_8	·001	...
Compound Tides.	Ter-diurnal . . . . . $(M_2K_1)_3$	·018	·121
	Quarter-diurnal . . . . . $(MS)_4$	·061	·096
	Ter-diurnal . . . . . $(2M_2K_1)_3$	·012	·086
	Quarter-diurnal . . . . . $(M_2N)_4$	·020	·040
	Semi-diurnal . . . . . $(2SM)_2$	·004	...
Long Period Tides.	Lunar monthly	·010	·046
	„ fortnightly	·007	·086
	Luni-solar „	·011	·007
	Solar-annual	·025	...
	„ semi-annual	·008	·040

Values of the Tidal Constants, Cochin, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87 or first year's observations at Cochin; and also the mean values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations:—

Short Period Tides.

A_0=2·422 feet.

S_1	H =	0·031	M_6	R =	0·010	Q_1	R =	0·056	T_2	R =	...
	κ = ζ =	161°·45		ζ =	107°·43		ζ =	91°·95		ζ =	...
S_2	H =	0·256		H =	0·009		H =	0·068		H =	...
	κ = ζ =	25°·81		κ =	95°·32		κ =	60°·49		κ =	...
S_4	H =	0·006	M_8	R =	0·003	L_2	R =	0·026	$(MS)_4$	R =	0·021
	κ = ζ =	203°·07		ζ =	63°·44		ζ =	260°·47		ζ =	259°·43
S_6	H =	0·007		H =	0·002		H =	0·027		H =	0·020
	κ = ζ =	226°·17		κ =	287°·28		κ =	24°·44		κ =	135°·40
S_8	H =	0·002	O_1	R =	0·252	N_2	R =	0·159	$(2SM)_2$	R =	0·005
	κ = ζ =	162°·47		ζ =	31°·00		ζ =	123°·38		ζ =	200°·10
M_1	R =	0·014		H =	0·306		H =	0·153		H =	0·004
	ζ =	178°·39		κ =	58°·21		κ =	300°·67		κ =	324°·13
	H =	0·010	K_1	R =	0·523	λ_2	R =	0·013	$2N_2$	R =	0·014
	κ =	5°·49		ζ =	200°·18		ζ =	200°·25		ζ =	155°·45
M_2	R =	0·757		H =	0·586		H =	0·013		H =	0·014
	ζ =	95°·56		κ =	50°·99		κ =	320°·82		κ =	274°·08
	H =	0·731	K_2	R =	0·068	ν_2	R =	0·035	$(M_2N)_4$	R =	0·025
	κ =	331°·52		ζ =	143°·76		ζ =	184°·04		ζ =	48°·41
M_3	R =	0·005		H =	0·089		H =	0·033		H =	0·023
	ζ =	164°·85		κ =	26°·05		κ =	355°·39		κ =	101°·66
	H =	0·005	P_1	R =	0·163	μ_2	R =	0·010	$(M_2K_1)_3$	R =	0·034
	κ =	158°·79		ζ =	266°·99		ζ =	56°·47		ζ =	44°·52
M_4	R =	0·030		H =	0·163		H =	0·009		H =	0·037
	ζ =	324°·44		κ =	52°·49		κ =	168°·39		κ =	131°·29
	H =	0·028	J_1	R =	0·022	R_2	R =	...	$(2M_2K_1)_3$	R =	0·016
	κ =	76°·36		ζ =	169°·93		ζ =	...		ζ =	206°·08
				H =	0·026		H =	...		H =	0·017
				κ =	77°·35		κ =	...		κ =	107°·19

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·016	351°·33	0·014	50°·00
„ fortnightly „	0·046	353·80	0·070	355·35
Luni-solar „ „	0·038	168·49	0·037	292·52
Solar-annual „	0·309	8·47	0·309	312·98
„ semi-annual „	0·134	264·94	0·134	153·95

The mean level of the sea (A_0) is 2·422 feet above the zero of the gauge.

The proportions of the several tides to the main lunar tide (M_2) are as follow:—

		Cochin, 1887.	Theoretical.
Semi-diurnal Tides.	Main solar	S_2	0·350	0·465
	Luni-solar	K_2	·122	·127
	Lunar elliptic	N_2	·209	·194
	„ „	L_2	·037	·028
	Evectional	ν_2	·045	·038
	„	λ_2	·018	·007
	Lunar elliptic of the second order	$2N_2$	·019	·026
	Variational	μ_2	·012	·024
Diurnal Tides.	Luni-solar	K_1	·802	·584
	Lunar declinational	O_1	·419	·415
	Solar „	P_1	·223	·193
	„ elliptic	Q_1	·093	·080
	Lunar „	J_1	·036	·033
	„	M_1	·014	·036
	Solar	S_1	·042	...

		Cochin, 1887.	Theoretical.
Over Tides	Lunar . . . . . M_2	0·007	0·013
	„ . . . . . M_4	·038	.....
	„ . . . . . M_6	·012	.....
	„ . . . . . M_8	·003	.....
	Solar . . . . . S_4	·008	.....
	„ . . . . . S_6	·010	.....
	„ . . . . . S_8	·003	.....
Compound Tides.	Ter-diurnal . . . . $(M_2K_1)_3$	·051	·121
	Quarter-diurnal . . . $(M S)_4$	·027	·096
	Ter-diurnal . . . . $(2M_2K_1)_3$	·023	·086
	Quarter-diurnal . . . $(M_2N)_4$	·031	·040
	Semi-diurnal . . . $(2SM)_2$	·005	.....
Long Period Tides.	Lunar-monthly	·019	·046
	„ fortnightly	·096	·086
	Luni-solar „	·051	·007
	Solar-annual	·423	.....
	„ semi-annual	·183	·040

Values of the Tidal Constants, Galle, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or second year's observations at Galle; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 2{\cdot}700$ feet.

S_1	R=	0·012	M_6	R=	0·003	Q_1	R=	0·019	T_2	R=	0·041
	$\kappa=\zeta=$	74°·88		$\zeta=$	75°·07		$\zeta=$	159°·20		$\zeta=$	147°·61
S_2	H=R=	0·357		H=	0·003		H=	0·024		H=	0·041
	$\kappa=\zeta=$	93°·95		$\kappa=$	335°·69		$\kappa=$	95°·68		$\kappa=$	58°·79
S_4	H=R=	0·004	M_8	R=	0·002	L_2	R=	0·032	$(MS)_4$	R=	0·000
	$\kappa=\zeta=$	245°·56		$\zeta=$	344°·06		$\zeta=$	101°·74		$\zeta=$	274°·01
S_6	H=R=	0·000		H=	0·002		H=	0·028		H=	0·006
	$\kappa=\zeta=$	135°·00		$\kappa=$	211°·54		$\kappa=$	6°·56		$\kappa=$	240°·89
S_8	H=R=	0·001	O_1	R=	0·042	N_2	R=	0·069	$(2SM)_2$	R=	0·012
	$\kappa=\zeta=$	258°·69		$\zeta=$	30°·68		$\zeta=$	187°·19		$\zeta=$	307°·06
				H=	0·052		H=	0·066		H=	0·012
				$\kappa=$	79°·25		$\kappa=$	41°·97		$\kappa=$	340°·19
M_1	R=	0·007	K_1	R=	0·145	λ_2	R=	0·013	$2N_2$	R=	0·021
	$\zeta=$	41°·19		$\zeta=$	98°·26		$\zeta=$	310°·16		$\zeta=$	323°·51
	H=	0·008		H=	0·165		H=	0·012		H=	0·020
	$\kappa=$	245°·42		$\kappa=$	17°·59		$\kappa=$	17°·88		$\kappa=$	66°·21
M_2	R=	0·545	K_2	R=	0·067	ν_2	R=	0·040	$(M_2N)_4$	R=	0·014
	$\zeta=$	90°·45		$\zeta=$	85°·65		$\zeta=$	330°·36		$\zeta=$	47°·12
	H=	0·525		H=	0·089		H=	0·038		H=	0·013
	$\kappa=$	57°·32		$\kappa=$	104°·40		$\kappa=$	16°·39		$\kappa=$	228°·78
M_3	R=	0·013	P_1	R=	0·049	μ_2	R=	0·027	$(M_2K_1)_3$	R=	0·007
	$\zeta=$	30°·72		$\zeta=$	294°·46		$\zeta=$	172°·45		$\zeta=$	142°·28
	H=	0·012		H=	0·049		H=	0·025		H=	0·008
	$\kappa=$	161°·03		$\kappa=$	14°·67		$\kappa=$	106°·19		$\kappa=$	28°·48
M_4	R=	0·012	J_1	R=	0·005	R_2	R=	0·018	$(2M_2K_1)_3$	R=	0·001
	$\zeta=$	230°·57		$\zeta=$	22°·89		$\zeta=$	89°·01		$\zeta=$	81°·25
	H=	0·011		H=	0·006		H=	0·018		H=	0·001
	$\kappa=$	164°·32		$\kappa=$	53°·28		$\kappa=$	357°·83		$\kappa=$	95°·67

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·019	218°·66	0·017	337°·01
„ fortnightly „ . . .	0·017	336 ·37	0·027	38 ·74
Luni-solar „ „	0·014	88 ·36	0·013	133 ·17
Solar-annual „	0·287	320 ·09	0·287	330 ·35
„ semi-annual „	0·089	81 ·60	0·089	102 ·12

The mean level of the sea (A_0) this year at Galle is 2·700 feet above the zero of the gauge. The value obtained from the previous year's observations is 2·656 feet, or about half an inch lower.

The main lunar tide (M_2) has a mean amplitude of 0·525 of a foot, which is almost identical with the former value 0·526. Its epoch is 57°·32, the value last year being 59°·80, giving a difference of 4 minutes in time.

The main solar tide (S_2) has an amplitude of 0·357 of a foot, which is identical with the value obtained in the preceding year. It is 68 per cent. of the main lunar tide, instead of 47 per cent. according to theory. Galle and Colombo continue to have larger proportions for this tide than any other stations. The epoch of the main solar tide (S_2) is 93°·95, its value during the preceding year being 96°·56, or 5 minutes in time later.

Of the two lunar elliptic tides (L_2 and N_2) the amplitudes as compared with the main tide are 0·053 and 0·126, and compare well with the previous year's values; the theoretical proportions are 0·028 and 0·194; thus again this year the former is greater and the latter is less than the theoretical value.

The lunar elliptic semi-diurnal tide of the second order ($2N_2$) is 0·038 of the main tide instead of 0·026 according to theory and is three times as large as the preceding year's value.

The solar elliptic tides (R_2 and T_2) have been computed this year and are 0·034 and 0·078 of the main tide. According to theory the latter should be only 0·027.

The proportions of the two evectional tides (λ_2 and ν_2) to the main tide are 0·023 and 0·072 instead of 0·007 and 0·038 the theoretical values. In the previous year they were found to be even larger.

The variational tide (μ_2) is 0·048 of the main tide which is identical with last year's value and exactly double the theoretical value.

The luni-solar semi-diurnal tide (K_2) is 17 per cent. of the main tide. The previous year it was 18 per cent. but theory makes it only 13 per cent. of the main tide. Its amplitude agrees very closely with last year's value and its epoch is 104°·40, whilst last year it was 91°·99.

The proportions of the diurnal tides to the main tide are as follow:—

		Galle, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·314	0·584
Lunar declinational	(O_1)	·099	·415
Solar „	(P_1)	·093	·193
„ elliptic	(Q_1)	·046	·080
Lunar „	(J_1)	·011	·033
„	(M_1)	·015	·036

It will be seen that as was the case in the previous year all the diurnal tide proportions at Galle are smaller than their theoretical values.

The proportions of the semi-diurnal tides on the other hand continue to be generally greater than the theoretical values.

Of the overtides, the only two of any significance are the lunar ter-diurnal (M_3) and quarter diurnal (M_4), which are 0·023 and 0·021 of the main tide, values which accord well with those obtained in the previous year.

The compound tides are all small and below the theoretical values, and agree fairly well with last year's determinations.

Of the long period tides, the lunar monthly is 0·032 instead of 0·046 of the main tide; in the previous year it was very much greater, being 0·127.

The lunar fortnightly tide is 0·051 of the main tide, last year's value being 0·038 and the theoretical being 0·086.

The luni-solar fortnightly tide is 0·025 of the main tide, which is identical with the value found last year; but theoretically it ought to be only 0·007.

The solar-annual tide is 55 per cent. of the main tide, last year it was 72 per cent. At Colombo it is also smaller, being only 47 per cent. of the main tide, whilst the proportion for the preceding year was 60 per cent. The epoch of this tide at Galle is 330°, the previous year's value being 314°.

The solar semi-annual tide is more than four times as great as its theoretical value, being 0·170 instead of 0·040 of the main tide, but it is less than the value, 0·184, previously obtained. Its epoch is 102°, whilst last year it was 125°.

Values of the Tidal Constants, Colombo, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or second year's observations at Colombo; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=2·261 feet.

S_1	H =	0·030	M_6	R =	0·003	Q_1	R =	0·022	T_2	R =	0·041
	κ = ζ =	59°·87		ζ =	166°·43		ζ =	45°·18		ζ =	23°·75
S_2	H = R =	0·389		H =	0·003		H =	0·027		H =	0·041
	κ = ζ =	101°·28		κ =	62°·83		κ =	88°·34		κ =	353°·08
S_4	H = R =	0·004	M_8	R =	0·001	L_2	R =	0·021	$(MS)_4$	R =	0·008
	κ = ζ =	248°·46		ζ =	6°·34		ζ =	194°·72		ζ =	302°·41
S_6	H = R =	0·002		H =	0·001		H =	0·018		H =	0·008
	κ = ζ =	214°·38		κ =	228°·21		κ =	46°·01		κ =	267°·88
S_8	H = R =	0·001	O_1	R =	0·081	N_2	R =	0·051	$(2SM)_2$	R =	0·005
	κ = ζ =	105°·95		ζ =	322°·93		ζ =	142°·52		ζ =	314°·12
				H =	0·101		H =	0·050		H =	0·005
				κ =	67°·36		κ =	46°·72		κ =	348°·65
M_1	R =	0·012	K_1	R =	0·204	λ_2	R =	0·033	$2N_2$	R =	0·013
	ζ =	357°·16		ζ =	174°·12		ζ =	297°·20		ζ =	279°·90
	H =	0·013		H =	0·231		H =	0·032		H =	0·012
	κ =	192°·29		κ =	35°·67		κ =	55°·85		κ =	122°·83
M_2	R =	0·584	K_2	R =	0·078	ν_2	R =	0·014	$(M_2N)_4$	R =	0·015
	ζ =	88°·57		ζ =	179°·33		ζ =	57°·56		ζ =	26°·57
	H =	0·563		H =	0·104		H =	0·014		H =	0·014
	κ =	54°·04		κ =	82°·45		κ =	49°·84		κ =	256°·23
M_3	R =	0·016	P_1	R =	0·062	μ_2	R =	0·018	$(M_2K_1)_3$	R =	0·002
	ζ =	37°·84		ζ =	233°·50		ζ =	165°·57		ζ =	280°·01
	H =	0·015		H =	0·062		H =	0·017		H =	0·002
	κ =	166°·04		κ =	11°·86		κ =	96°·51		κ =	107·03
M_4	R =	0·015	J_1	R =	0·005	R_2	R =	0·059	$(2M_2K_1)_3$	R =	0·002
	ζ =	243°·25		ζ =	137°·56		ζ =	129·03		ζ =	14°·04
	H =	0·014		H =	0·006		H =	0·059		H =	0·002
	κ =	174°·19		κ =	59°·88		κ =	339°·70		κ =	83°·42

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·040	260°·12	0·035	321°·39
„ fortnightly „	0·040	77 ·35	0·064	13 ·97
Luni-solar „ „	0·012	25 ·72	0·012	60 ·25
Solar-annual „	0·267	15 ·24	0·267	326 ·88
„ semi-annual „	0·060	179 ·99	0·060	83 ·27

The mean level of the sea (A_0) is 2·261 feet above the zero of the gauge; last year it was found to be 2·208 or more than half an inch lower.

The main lunar tide (M_2) has an amplitude of 0·563 of a foot; in the previous year it was 0·546. The epoch is 54°·04, last year's value being 52°·78. These values do not differ much from the corresponding values at Galle.

The amplitude of the main solar tide (S_2) is 0·389 of a foot, last year's value being 0·362. It is 0·691 of the main tide, which is one and half times as great as the value assigned by theory; but it is very accordant with the value obtained last year. The epoch is 101°·28 which is not far from last year's value, and these values also correspond fairly with those obtained at Galle.

The luni-solar semi-diurnal tide (K_2) is 0·185 of the main tide; last year it was 0·132, or almost the same as the theoretical value 0·127. The epoch is 82° and differs considerably from last year's value which was 109°.

The smaller lunar elliptic tide (L_2) is 0·032 of the main tide, which approaches very nearly the theoretical value 0·028; but the larger component (N_2) is 0·089 of the main tide, or a little less than half its theoretical proportion 0·194.

The lunar elliptic tide of the second order ($2N_2$) is 0·021 of the main tide and accords well with its theoretical value 0·026. In the previous year it was 0·020.

The proportions of the two evectional tides (λ_2 and ν_2) to the main tide are 0·057 and 0·025 respectively; theoretically they should be 0·007 and 0·038.

The proportion of the variational tide (μ_2) is 0·030 instead of 0·024, the theoretical value; in the previous year it was 0·037.

The proportions of the diurnal tides to the main tide are as follow :—

		Colombo, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·410	0·584
Lunar declinational	(O_1)	·179	·415
Solar „	(P_1)	·110	·193
„ elliptic	(Q_1)	·048	·080
Lunar „	(J_1)	·011	·033
„	(M_1)	·023	·036

Thus all the diurnal tides are considerably less than their theoretical values and have a general accordance with the values obtained last year.

Of the over tides, the lunar ter-diurnal (M_3) and quarter-diurnal (M_4) are 0·027 and 0·025 of the main tide and agree closely with last year's values; the others are insignificant.

The compound tides as at Galle are all small and below the theoretical values.

Of the long period tides the lunar monthly is 0·062, the theoretical value being 0·046; in the previous year it was 0·079. Its epoch 321° is not accordant with last year's value 18°.

The lunar fortnightly is 0·114 of the main tide; in the preceding year it was 0·060; theoretically it ought to be 0·086. The mean of the two years is 0·087. Its epoch is 14°, whilst last year it was 321°.

The luni-solar fortnightly tide is 0·021 of the main tide; last year it was 0·026; but the theoretical value is only 0·007. The results are very close to those obtained at Galle which were 0·025 in both the corresponding years. The epoch is 60°; in the previous year it was 36°.

The solar-annual tide is 47 per cent. of the main tide, being less than the proportion obtained last year. Its epoch is 327°, the previous year's value being 309°.

The solar semi-annual tide is 0·107 of the main tide; last year it was 0·225, and the theoretical value is 0·040. The epoch is 83°; last year it was 128°.

Values of the Tidal Constants, Negapatam, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or third year's accepted observations at Negapatam; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0 = 1·811 feet.

S_1	H = R =	0·040	M_6	R =	0·013	Q_1	R =	0·006	T_2	R =	...
	κ = ζ =	95°·91		ζ =	66°·14		ζ =	246°·54		ζ =	...
S_2	H = R =	0·284		H =	0·011		H =	0·007		H =	...
	κ = ζ =	280°·91		κ =	124°·49		κ =	284°·01		κ =	...
S_4	H = R =	0·006	M_8	R =	0·004	L_2	R =	0·045	$(MS)_4$	R =	0·019
	κ = ζ =	106°·61		ζ =	294°·31		ζ =	224°·54		ζ =	186°·16
S_6	H = R =	0·001		H =	0·004		H =	0·039		H =	0·018
	κ = ζ =	146°·31		κ =	252°·11		κ =	264°·92		κ =	85°·61
S_8	H = R =	0·001	O_1	R =	0·070	N_2	R =	0·174	$(2SM)_2$	R =	0·006
	κ = ζ =	240°·95		ζ =	325°·26		ζ =	292°·87		ζ =	97°·60
				H =	0·087		H =	0·168		H =	0·006
				κ =	318°·05		κ =	237°·00		κ =	198°·15
M_1	R =	0·016	K_1	R =	0·198	λ_2	R =	0·016	$2N_2$	R =	0·036
	ζ =	314°·26		ζ =	78°·94		ζ =	82°·43		ζ =	230°·52
	H =	0·017		H =	0·224		H =	0·016		H =	0·035
	κ =	303°·16		κ =	346°·55		κ =	306°·94		κ =	219°·33
M_2	R =	0·767	K_2	R =	0·058	ν_2	R =	0·040	$(M_2N)_4$	R =	0·025
	ζ =	349°·86		ζ =	289°·75		ζ =	94°·63		ζ =	277°·13
	H =	0·739		H =	0·078		H =	0·039		H =	0·024
	κ =	249°·31		κ =	285°·04		κ =	209°·02		κ =	120°·70
M_3	R =	0·004	P_1	R =	0·080	μ_2	R =	0·017	$(M_2K_1)_3$	R =	0·010
	ζ =	236°·31		ζ =	247°·68		ζ =	328°·80		ζ =	261°·96
	H =	0·004		H =	0·080		H =	0·016		H =	0·010
	κ =	85°·49		κ =	339°·72		κ =	127°·70		κ =	69°·02
M_4	R =	0·018	J_1	R =	0·016	R_2	R =	...	$(2M_2K_2)_3$	R =	0·006
	ζ =	272°·28		ζ =	134°·74		ζ =	...		ζ =	83°·23
	H =	0·017		H =	0·019		H =	...		H =	0·006
	κ =	71°·18		κ =	356°·72		κ =	...		κ =	334°·53

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide . . .	0·086	2°·93	0·076	318°·25
„ fortnightly „ . . .	0·050	260 ·19	0·080	354 ·06
Luni-solar „ „ . . .	0·026	341 ·10	0·025	81 ·65
Solar-annual „ . . .	0·348	250 ·84	0·348	248 ·80
„ semi-annual „ . . .	0·300	132 ·71	0·300	128 ·63

Previously to the year 1885-86, three years' observations were taken, the last of which had to be rejected.

The mean level of the sea (A_0) as obtained this year is 1·811 feet above the zero of the gauge, which is the lowest value yet obtained.

The mean amplitude of the main lunar tide (M_2) is 0·739 of a foot, and although the largest yet obtained, it is very close to the previous values. The epoch is 249°·3, the mean of the two former values being 251°·6.

The main solar tide (S_2) has an amplitude of 0·284 of a foot, which is the largest yet obtained here. The mean of the two previous years' values, which closely agree, is 0·274. The epoch this year is 280°·9. The average of the two former values is 284°·2, or a difference of about 6½ minutes.

The luni-solar semi-diurnal tide (K_2) is a little less than the theoretical value, being 0·106 instead of 0·127. The mean of the two former results is also 0·106. Its epoch is 285°·04 and is almost identical with the mean of the former values.

The smaller lunar elliptic tide (L_2) is 0·053 of the main tide, or nearly double the theoretical value 0·028. The larger component (N_2) is 0·227 of the main tide; theoretically it should be 0·194.

The lunar elliptic tide of the second order ($2N_2$) is 0·047 of the main tide or nearly twice as large as its theoretical value 0·026.

The evectional tides (λ_2 and ν_2) are 0·022 and 0·053 respectively of the main tide. Their theoretical values are 0·007 and 0·038.

The variational tide (μ_2) is 0·022 of the main tide, which agrees closely with the theoretical value 0·024; the two previous values were 0·025 and 0·033.

The proportions of the diurnal tides to the main tide are as follow :—

	Negapatam, 1885-86.	Theoretical.
Luni-solar (K_1)	0·303	0·584
Lunar declinational (O_1)	0·118	0·415
Solar „ (P_1)	0·108	0·193
„ elliptic (Q_1)	0·009	0·080
Lunar „ (J_1)	0·026	0·033
„ (M_1)	0·023	0·036

They have always been very much less than the theoretical proportions.

All the overtides, only three of which are of significance, agree very closely with the values previously obtained.

The proportions of the compound tides to the main tide, which agree very well with the previous determinations, are all less than the theoretical values.

Of the long period tides, the lunar monthly is this year 0·103 of the main tide, being more than double last year's value 0·044, which is very nearly the theoretical proportion 0·046; but it is less than the first year's value, which was as much as 0·114.

The lunar fortnightly tide is 0·108 of the main tide; the first year's value was 0·086, which is the theoretical value, but last year it was only 0·023 of the main tide.

The luni-solar fortnightly tide is 0·034 of the main tide, which is almost five times as large as the theoretical value, 0·007; but in the other two years it was very much larger, being 0·118 and 0·133 of the main tide.

The solar-annual tide is 0·471 of the main tide, which is much less than the other two years' values, 0·763 and 0·718. Its epoch is 249°, or 17° later than the mean of the two previous values, which were very near each other.

The solar semi-annual tide is 0·406 of the main tide, a value which is more than ten times the theoretical proportion 0·040, but in the two previous years the values were still higher, being 0·435 and 0·562 of the main tide. Its epoch is 129° and agrees well with the previous values.

Values of the Tidal Constants, Negapatam, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87 or fourth year's accepted observations at Negapatam; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations :—

Short Period Tides.

A_0=2·048 feet.

S_1	H=	0·021	M_6	R=	0·011	Q_1	R=	0·001	T_2	R=	0·037
	κ= ζ=	97°·36		ζ=	136°·61		ζ=	255°·96		ζ=	320°·11
S_2	H=R=	0·261		H=	0·010		H=	0·001		H=	0·037
	κ= ζ=	281°·07		κ=	135°·14		κ=	310°·17		κ=	243°·38
S_4	H=R=	0·006	M_8	R=	0·003	L_2	R=	0·045	$(MS)_4$	R=	0·018
	κ= ζ=	125°·88		ζ=	336°·50		ζ=	346°·47		ζ=	107°·61
S_6	H=R=	0·001		H=	0·003		H=	0·047		H=	0·018
	κ= ζ=	251°·57		κ=	334°·54		κ=	219°·13		κ=	107°·12
S_8	H=R=	0·001	O_1	R=	0·072	N_2	R=	0·156	$(2SM)_2$	R=	0·003
	κ= ζ=	218°·66		ζ=	227°·60		ζ=	276°·15		ζ=	229°·97
				H=	0·087		H=	0·151		H=	0·003
				κ=	325°·84		κ=	231°·62		κ=	230°·46
M_1	R=	0·023	K_1	R=	0·194	λ_2	R=	0·032	$2N_2$	R=	0·016
	ζ=	36°·97		ζ=	85°·01		ζ=	189°·28		ζ=	271°·85
	H=	0·016		H=	0·216		H=	0·031		H=	0·015
	κ=	289°·39		κ=	348°·58		κ=	324°·38		κ=	183°·27
M_2	R=	0·730	K_2	R=	0·074	ν_2	R=	0·016	$(M_2N)_4$	R=	0·051
	ζ=	251°·48		ζ=	298°·24		ζ=	229°·44		ζ=	226°·65
	H=	0·706		H=	0·097		H=	0·015		H=	0·048
	κ=	250°·99		κ=	286°·00		κ=	273°·36		κ=	181°·63
M_3	R=	0·002	P_1	R=	0·075	μ_2	R=	0·016	$(M_2K_1)_3$	R=	0·014
	ζ=	253°·30		ζ=	255°·24		ζ=	104°·30		ζ=	240°·74
	H=	0·002		H=	0·075		H=	0·015		H=	0·015
	κ=	72°·27		κ=	347°·52		κ=	103°·32		κ=	143°·81
M_4	R=	0·052	J_1	R=	0·012	R_2	R=	0·031	$(2M_2K_1)_3$	R=	0·009
	ζ=	76°·56		ζ=	89°·51		ζ=	43°·55		ζ=	240°·09
	H=	0·021		H=	0·014		H=	0·031		H=	0·009
	κ=	75°·58		κ=	34°·82		κ=	300°·28		κ=	335°·54

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·009	302°·83	0·008	346°·87
„ fortnightly „	0·065	22 ·38	0·098	5 ·40
Luni-solar „ „	0·027	50 ·67	0·026	51 ·16
Solar-annual „	0·444	231 ·87	0·444	229 ·60
„ semi-annual „	0·328	133 ·60	0·328	129 ·04

The mean of level of the sea (A_0) in the year 1886-87 is 2·048 feet above the zero of the gauge, and is identical with the highest value previously obtained, which was in 1882-83.

The value of the mean amplitude (H) of the main lunar tide (M_2) is 0·706 of a foot, and is the lowest yet obtained. Its epoch is 250°·99 and agrees very well with former values.

The amplitude of the main solar tide (S_2) is 0·261 of a foot; all the former values are slightly larger. It is 37 per cent. of the main tide; theoretically it should be 47 per cent. The epoch of this tide is 281°·07 which accords well with previous values.

The value of the luni-solar semi-diurnal tide (K_2) which has hitherto been slightly less than the theoretical value 0·127, is this year slightly in excess of it, being 0·137.

Of the two lunar elliptic tides (L_2 and N_2) the smaller component (L_2) is 0·067, and the larger component (N_2) is 0·214 of the main tide. Theoretically they should be 0·028 and 0·194.

The lunar elliptic tide of the second order ($2N_2$) is 0·021 of the main tide instead of 0·026, the theoretical value.

Of the two evectional tides (λ_2 and ν_2) the component which should be the smaller (λ_2) is 0·044 of the main tide, or six times as large as its theoretical value 0·007. The component (ν_2) is on the other hand very much smaller than it ought to be theoretically, being only 0·021 instead of 0·038 of the main tide.

The two solar elliptic tides (R_2 and T_2) have been computed from the observations for the two years 1885-86 and 1886-87. Their amplitudes are 0·044 and 0·052 respectively of the main tide, values which agree very well with those computed in 1882-83, although considerably in excess of the theoretical.

The variational tide (μ_2) is very accordant with the theoretical and with the former year's values.

The proportions of the diurnal tides to the main tide are as follow :—

		Negapatam, 1886-87.	Theoretical.
Luni-solar	(K_1)	0·306	0·584
Lunar declinational	(O_1)	0·123	0·415
Solar „	(P_1)	0·106	0·193
„ elliptic	(Q_1)	0·001	0·080
Lunar „	(J_1)	0·020	0·033
„	(M_1)	0·023	0·036

These tides are as usual very much less than their theoretical values.

All the overtides of which the only ones of any significance are the solar quarter-diurnal (S_4), the lunar quarter-diurnal (M_4) and the sexter-diurnal (M_6) agree very closely with the values previously obtained.

The proportions of the compound tides to the main tide are as follow :—

	Negapatam, 1886-87.	Theoretical.
$(M_2K_1)_3$	0·021	0·121
$(MS)_4$	0·025	0·096
$(2M_2K_1)_3$	0·013	0·086
$(M_2N)_4$	0·068	0·040
$(2SM)_2$	0·004	...

Of the long-period tides the lunar monthly is 0·011 of the main tide instead of 0·046, the theoretical value, and this is the lowest value yet obtained.

The lunar fortnightly tide is 0·139 of the main tide. The theoretical value is 0·086; the former values are given in the discussion for the preceding year.

The luni-solar fortnightly tide is 0·037 of the main tide instead of 0·007, the theoretical value, and agrees well with the preceding year's value.

The solar-annual tide is 63 per cent. of the main tide, which is less than last year's value, but greater than the values obtained from the first two years' observations. Its epoch is 230°, or 19° earlier than last year.

The solar semi-annual tide is 0·465 of the main tide, which agrees with the mean of former values. Its epoch is 129°, the value obtained in the preceding year.

Values of the Tidal Constants, Cocanada, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87 or first year's observations at Cocanada; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations:—

Short Period Tides.

$A_0 = 5{\cdot}488$ feet.

S_1	H =	0·036	M_6	R =	0·016	Q_1	R =	0·014	T_2	R =	...
	R =			ζ =	183°·23		ζ =	44°·13		ζ =	...
	κ = ζ =	92°·89		H =	0·014		H =	0·017		H =	..
S_2	H =	0·644		κ =	97°·59		κ =	35°·95		κ =	...
	R =		M_8	R =	0·002	L_2	R =	0·071	$(MS)_4$	R =	0·015
	κ = ζ =	284°·85		ζ =	60°·64		ζ =	164°·07		ζ =	39°·23
S_4	H =	0·003		H =	0·002		H =	0·075		H =	0·014
	R =			κ =	66°·46		κ =	272°·21		κ =	130°·69
	κ = ζ =	125°·54	O_1	R =	0·110	N_2	R =	0·319	$(2SM)_2$	R =	0·015
S_6	H =	0·003		ζ =	153°·44		ζ =	340°·13		ζ =	306°·19
	R =			H =	0·133		H =	0·308		H =	0·015
	κ = ζ =	204°·78		κ =	332°·93		κ =	243°·91		κ =	214°·74
S_8	H =	0·003									
	R =										
	κ = ζ =	220°·60									

Short Period Tides—continued.

$A_0 = 5{\cdot}488$ feet.

M_1	R =	0·029	K_1	R =	0·311	λ_2	R =	0·008	$2N_2$	R =	0·045
	ζ =	222°·31		ζ =	65°·87		ζ =	91°·45		ζ =	165°·59
	H =	0·019		H =	0·347		H =	0·008		H =	0·043
	κ =	341°·40		κ =	340°·18		κ =	82°·90		κ =	241°·70
M_2	R =	1·537	K_2	R =	0·135	ν_2	R =	0·073	$(M_2N)_4$	R =	0·033
	ζ =	160°·83		ζ =	277°·03		ζ =	179°·37		ζ =	125°·17
	H =	1·486		H =	0·175		H =	0·071		H =	0·031
	κ =	252°·29		κ =	286°·38		κ =	190°·83		κ =	120°·41
M_3	R =	0·007	P_1	R =	0·099	μ_2	R =	0·020	$(M_2K_1)_3$	R =	0·022
	ζ =	208°·97		ζ =	262°·83		ζ =	73°·82		ζ =	290°·15
	H =	0·006		H =	0·099		H =	0·019		H =	0·024
	κ =	346°·15		κ =	344°·27		κ =	256°·73		κ =	295°·91
M_4	R =	0·028	J_1	R =	0·024	R_2	R =	...	$(2M_2K_1)_3$	R =	0·011
	ζ =	285°·83		ζ =	238°·83		ζ =	...		ζ =	57°·82
	H =	0·026		H =	0·028		H =	...		H =	0·011
	κ =	108°·73		κ =	338°·46		κ =	...		κ =	326°·42

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·032	9°·84	0·029	197°·51
„ fortnightly „	0·052	142 ·15	0·078	54 ·62
Luni-solar „ „	0·034	110 ·05	0·033	18 ·60
Solar-annual „	0·853	191 ·08	0·853	199 ·64
„ semi-annual „	0·403	91 ·51	0·403	108 ·63

The mean level of the sea (A_0) is 5·488 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow :—

			Cocanada, 1886-87.	Theoretical.
Semi Diurnal Tides.	Main solar	S_2	0·433	0·465
	Luni-solar	K_2	·118	·127
	Lunar elliptic	N_2	·207	·194
	„ „	L_2	·050	·028
	Evectional	ν_2	·048	·038
	„	λ_2	·005	·007
	Lunar elliptic of the 2nd order	$2N_2$	·029	·026
	Variational	μ_2	·013	·024
Diurnal Tides.	Luni-solar	K_1	·234	·584
	Lunar declinational	O_1	·090	·415
	Solar „	P_1	·067	·193
	„ elliptic	Q_1	·011	·080
	Lunar „	J_1	·019	·033
	„	M_1	·013	·036
	Solar	S_1	·024	...
Over Tides	Lunar	M_8	·004	·013
	„	M_4	·017	...
	„	M_6	·009	...
	„	M_8	·001	...
	Solar	S_4	·002	...
	„	S_6	·002	...
	„	S_8	·002	...

		Cocanada, 1886-87.	Theoretical.
Compound Tides.	Ter-diurnal . . . . $(M_3K_1)_3$	0·016	0·121
	Quarter-diurnal . . . . $(MS)_4$	·009	·096
	Ter-diurnal . . . . $(2M_3K_1)_3$	·007	·086
	Quarter-diurnal . . . . $(M_2N)_4$	·021	·040
	Semi-diurnal . . . . $(2SM)_2$	·010	...
Long period Tides.	Lunar monthly	·020	·046
	„ fortnightly	·052	·086
	Luni solar „	·022	·007
	Solar-annual	·574	...
	„ semi-annual	·271	·040

The foregoing values agree remarkably well with those obtained at the neighbouring tidal station of Vizagapatam, the observatory at which was closed on the termination of the 1884-85 observations.

Values of the Tidal Constants, Dublat, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or fifth and final year's observations at Dublat; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 9{\cdot}434$ feet.

S_1	H =	0·047	M_6	R =	0·008	Q_1	R =	0·008	T_2	R =	...
	κ = ζ =	131°·20		ζ =	14°·62		ζ =	207°·18		ζ =	...
S_2	H = R =	2·099		H =	0·007		H =	0·010		H =	...
	κ = ζ =	330°·45		κ =	180°·69		κ =	57°·70		κ =	...
S_4	H = R =	0·011	M_8	R =	0·010	L_2	R =	0·278	$(MS)_4$	R =	0·080
	κ = ζ =	237°·49		ζ =	317°·01		ζ =	274°·03		ζ =	15°·65
S_6	H = R =	0·002		H =	0·009		H =	0·245		H =	0·077
	κ = ζ =	259°·38		κ =	298°·43		κ =	301°·84		κ =	191°·00
S_8	H = R =	0·009	O_1	R =	0·158	N_2	R =	0·915	$(2SM)_2$	R =	0·045
	κ = ζ =	129°·89		ζ =	98°·99		ζ =	137°·33		ζ =	11°·56
				H =	0·196		H =	0·882		H =	0·044
				κ =	335°·68		κ =	286°·51		κ =	196°·20
M_1	R =	0·027	K_1	R =	0·435	λ_2	R =	0·169	$2N_2$	R =	0·153
	ζ =	339°·89		ζ =	53°·77		ζ =	171°·59		ζ =	140°·51
	H =	0·027		H =	0·493		H =	0·163		H =	0·147
	κ =	291°·07		κ =	353°·56		κ =	325°·19		κ =	263°·53
M_2	R =	4·776	K_2	R =	0·518	ν_2	R =	0·340	$(M_2N)_4$	R =	0·213
	ζ =	118°·44		ζ =	267°·62		ζ =	259°·04		ζ =	55°·33
	H =	4·603		H =	0·691		H =	0·328		H =	0·198
	κ =	293°·80		κ =	327°·33		κ =	276°·15		κ =	19°·88
M_3	R =	0·052	P_1	R =	0·148	μ_2	R =	0·152	$(M_3K_1)_3$	R =	0·066
	ζ =	53°·49		ζ =	290°·12		ζ =	19°·24		ζ =	76°·46
	H =	0·049		H =	0·148		H =	0·141		H =	0·072
	κ =	136°·53		κ =	349°·66		κ =	9°·96		κ =	191°·61
M_4	R =	0·087	J_1	R =	0·027	R_2	R =	...	$(2M_2K_1)_3$	R =	0·029
	ζ =	168°·93		ζ =	52°·50		ζ =	...		ζ =	46°·13
	H =	0·081		H =	0·033		H =	...		H =	0·031
	κ =	159°·65		κ =	17°·33		κ =	...		κ =	97°·06

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·023	140°·84	0·020	171°·00
„ fortnightly „	0·020	203 ·94	0·032	85 ·92
Luni-solar „ „	0·044	200 ·93	0·042	25 ·57
Solar-annual „	0·787	123 ·17	0·787	153 ·64
„ semi-annual „	0·146	75 ·86	0·146	136 ·80

The mean level of the sea (A_0) at Dublat is 9·434 feet above the new zero of the gauge, which is equivalent to a height of 14·263 feet above the old zero to which all previous values have been referred. The mean of all the values is 14·390 feet, or 1½ inches higher.

The mean amplitude (H) of the main lunar tide (M_2) is 4·603 feet, which is very accordant with the former values, the mean of all the determinations being 4·608. The epoch is 293°·80 which also agrees well with previous values.

The main solar tide (S_2) has an amplitude of 2·099 feet, which is nearly equal to the mean value 2·107. Its proportion to the main tide is 0·456, which is almost identical with the mean of the five years' determinations 0·457. The theoretical value is just 1 per cent. greater. Its epoch is well established, the values obtained during the five years' observations being very accordant. The mean value is 327°·75.

The luni-solar semi-diurnal tide (K_2) is 0·150 of the main tide, being the largest proportion obtained; but the average of the five years' determinations is 0·135, which does not differ much from the theoretical value 0·127. The epoch is 327°·33, or about 5 minutes later than the average value 324°·78.

The smaller component of the lunar elliptic tide (L_2) is 0·053 of the main tide, the mean of the five years being 0·042, whilst the theoretical value is about half this proportion. The larger component (N_2) is 0·192 of the main tide and agrees closely with the mean, 0·194, of the five years' determinations, which is identical with the theoretical value.

The lunar elliptic tide of the second order ($2N_2$) is 0·032 of the main tide, which compares well with the theoretical value 0·026. The average obtained from all the observations is 0·034.

The smaller component of the evectional tide (λ_2) is 0·035 of the main tide, and agrees closely with the mean 0·032, but theoretically it should be as small as 0·007. The larger component (ν_2) is about twice as large as it ought to be by theory. This year's value is the largest, being 0·071, while the mean is 0·053, and the theoretical value is 0·038.

The variational tide (μ_2) has a proportion to the main tide of 0·031, the mean value is 0·032, and the theoretical is 0·024.

The proportions of the diurnal tides to the main tide are as follow:—

		Dublat, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·107	0·584
Lunar declinational	(O_1)	0·043	0·415
Lunar „	(P_1)	0·032	0·193
„ elliptic	(Q_1)	0·002	0·080
Lunar „	(J_1)	0·007	0·033
„	(M_1)	0·006	0·036

The values of these tides obtained during the five years' observations are remarkably accordant, and are all much below the theoretical proportions.

Of the overtides, the lunar quarter-diurnal (M_4) is the largest, having a proportion of 0·018 to the main tide, and agrees very well with former values. Its epoch is also well established, being 148°·95.

The proportions of the compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·016
$(MS)_4$	0·017
$(2M_2K_1)_3$	0·007
$(M_2N)_4$	0·043
$(2SM)_2$	0·010

These are all small and, with the exception of $(MN)_4$, which this year is almost identical with the theoretical value, are very accordant with the former values.

With reference to the long period tides their proportions to the main tide have a general agreement with previous values. With the exception of the luni-solar fortnightly tide the mean proportions obtained during the five years' observations are less than the theoretical proportions. The epochs of these tides are divergent, with the exception of that of the solar annual, which is 153°·6, or only 3° more than the value obtained from the five years' observations.

Values of the Tidal Constants, Diamond Harbour, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 or fourth year's observations at Diamond Harbour; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=8·897 feet.

S_1	H=	R=	0·092	M_6	R =	0·157	Q_1	R =	0·016	T_2	R =	0·317
	κ =	ζ =	161° 09		ζ =	9°·70		ζ =	136°·64		ζ =	178°·44
S_2	H=	R=	2·202		H =	0·141		H =	0·019		H =	0·317
	κ =	ζ =	26°·49		κ =	112°·37		κ =	301°·12		κ =	86°·44
S_4	H=	R=	0·123	M_8	R =	0·061	L_2	R =	0·330	$(MS)_4$	R =	0·754
	κ =	ζ =	328°·73		ζ =	91°·82		ζ =	340°·96		ζ =	134°·34
S_6	H=	R=	0·013		H =	0·053		H =	0·280		H =	0·728
	κ =	ζ =	269°·56		κ =	348°·72		κ =	344°·23		κ =	288°·57
S_8	H=	R=	0·007	O_1	R =	0·176	N_2	R =	0·979	$(2SM)_2$	R =	0·072
	κ =	ζ =	285°·95		ζ =	123°·09		ζ =	243°·83		ζ =	65°·39
					H =	0·217		H =	0·945		H =	0·069
					κ =	350°·44		κ =	335°·79		κ =	271°·17
M_1	R =		0·045	K_1	R =	0·441	λ_2	R =	0·199	$2N_2$	R =	0·173
	ζ =		328°·3		ζ =	88°·84		ζ =	238°·47		ζ =	284°·12
	H =		0·052		H =	0·498		H =	0·192		H =	0·167
	κ =		202°·53		κ =	14°·32		κ =	356°·71		κ =	313°·80
M_2	R =		5·324	K_2	R =	0·542	ν_2	R =	0·401	$(M_2N)_4$	R =	0·091
	ζ =		190°·49		ζ =	352°·28		ζ =	320°·33		ζ =	138°·86
	H =		5·135		H =	0·718		H =	0·387		H =	0·085
	κ =		344°·71		κ =	22°·76		κ =	330°·53		κ =	25°·04
M_3	R =		0·065	P_1	R =	0·184	μ_2	R =	0·364	$(M_2K_1)_3$	R =	0·146
	ζ =		185°·80		ζ =	294°·90		ζ =	133° 60		ζ =	199° 04
	H =		0·062		H =	0·184		H =	0·338		H =	0·159
	κ =		237°·14		κ =	11°·94		κ =	82°·05		κ =	278°·74
M_4	R =		0·809	J_1	R =	0·029	R_2	R =	0·175	$(2M_2K_1)_3$	R =	0·056
	ζ =		300°·56		ζ =	39° 22		ζ =	104°·52		ζ =	197°·28
	H =		0·753		H =	0·035		H =	0·175		H =	0·059
	κ =		249°·01		κ =	28°·37		κ =	16° 53		κ =	220° 25

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·164	314°·32	0·145	16°·59
„ fortnightly „	0·099	160 ·87	0·155	40 ·40
Luni-solar „	0·439	190 ·38	0·424	36 ·15
Solar-annual „	0·991	129 ·86	0·991	142 ·83
„ semi-annual „	0·069	124 ·18	0·069	150 ·10

The mean level of the water (A_0) for 1884-85 is 8·897 feet above the zero of the gauge, which is the lowest height yet reached. The highest was 1⅛ inches greater and was reached in 1882-83.

The mean amplitude (H) of the main lunar tide (M_2) is 5·135 feet, which is somewhat less than previous values. The epoch is 344°·7, which is very accordant with all the former values.

The main solar tide (S_2) has an amplitude this year of 2·202 feet, which agrees well with former values. It is 0·429 of the main tide, or about 3½ per cent. less than the theoretical value 0·465. Its epoch, 26°·5, also agrees very closely with the values previously obtained.

The luni-solar semi-diurnal tide (K_2) is 0·140 of the main tide, which, although slightly in excess of the theoretical value, 0·127, agrees well with the mean of previous determinations. The epoch, 22°·8, agrees well with previous determinations.

The smaller component (L_2) of the lunar elliptic tide is 0·055 of the main tide, or twice as large as the theoretical value 0·028, whilst the larger component (N_2) has a proportion of 0·184, or 1 per cent. less than the theoretical value 0·194. These proportions accord well with the former results. The epochs of these tides are very regular throughout.

The lunar elliptic tide of the second order ($2N_2$) is 0·033 of the main tide, according to theory it should be 0·026.

The solar elliptic tides (R_2 and T_2) have been computed from the observations for 1883-84 and 1884-85. The amplitudes are 0·034 and 0·062 respectively of the main tide. The latter is more than double the theoretical value 0·027, and four times as large as the value, 0·015, obtained before. The former does not differ much from the determination in 1882-83, which was 0·042.

The evectional tides (λ_2 and ν_2) are 0·037 and 0·075 of the main tide, whilst according to theory they should be only 0·007 and 0·038, values which were approached in former years.

The variational tide (μ_2) is 0·066 of the main tide, which agrees with former values, but is much in excess of the theoretical value, 0·024.

The proportions of the diurnal tides to the main tide are as follow :—

		Diamond Harbour, 1884-85.	Theoretical.
Luni-solar	(K_1)	0·097	0·584
Lunar declinational	(O_1)	0·042	0·415
Solar „	(P_1)	0·036	0·193
„ elliptic	(Q_1)	0·004	0·080
Lunar „	(J_1)	0·007	0·033
„	(M_1)	0·010	0·03

These proportions, which are all less than the theoretical values, agree very well with the former results.

The largest overtide is the lunar quarter-diurnal (M_4) which has an amplitude equal to ·15 per cent. of the main tide. This proportion has been maintained every year.

The proportions of the compound tides to the main tide are as follow :—

$(M_2K_1)_3$	0·031
$(MS)_4$	0·142
$(2M_2K_1)_3$	0·011
$(M_2N)_4$	0·017
$(2SM)_2$	0·013

These proportions correspond fairly well with former values.

The proportions of the long period tides to the main tide accord well with former values, and are less than the theoretical, with the exception of the luni-solar fortnightly tide, which is 0·083 or 12 times its theoretical value. The epochs of the lunar fortnightly, the luni-solar fortnightly and the solar annual agree very well with their former values, but the accordance of the epochs of the lunar monthly is not so good, and the values obtained for the solar semi-annual are very divergent.

Values of the Tidal Constants, Diamond Harbour, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or fifth and final year's observations at Diamond Harbour; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=8·804 feet.

S_1	H=	·101	M_6	R=	·161	Q_1	R=	·013	T_2	R=	...
	κ = ζ =	162°·94		ζ =	67°·24		ζ =	221°·48		ζ =	...
S_2	H= R=	2·199		H=	·144		H=	·016		H=	...
	κ = ζ =	25°·98		κ =	110°·03		κ =	43°·56		κ =	...
S_4	H= R=	·123	M_8	R=	·062	L_2	R=	·315	$(MS)_4$	R=	·736
	κ = ζ =	326°·18		=	57°·00		ζ =	136°·93		ζ =	34°·00
S_6	H= R=	·006		H=	·053		H=	·276		H=	·709
	κ = ζ =	233°·13		κ =	354°·04		κ =	8°·11		κ =	288°·26
S_8	H= R=	·002	O_1	R=	·188	N_2	R=	1·069	$(2SM)_2$	R=	·077
	κ = ζ =	175°·03		ζ =	15°·19		ζ =	243°·74		ζ =	184°·02
				H=	·233		H=	1·030		H=	·074
				κ =	348°·26		κ =	347°·01		κ =	289°·76
M_1	R=	·032	K_1	R=	·454	λ_2	R=	·277	$2N_2$	R=	·153
	ζ =	108°·90		ζ =	91°·25		ζ =	329°·24		ζ =	8°·83
	H=	·032		H=	·515		H=	·267		H=	·147
	κ =	277°·22		κ =	13°·49		κ =	358°·05		κ =	321°·11
M_2	R=	5·348	K_2	R=	·466	ν_2	R=	·211	$(M_2N)_4$	R=	·124
	ζ =	99°·56		ζ =	5°·49		ζ =	359°·59		ζ =	70°·18
	H=	5·154		H=	·622		H=	·203		H=	·116
	κ =	344°·82		κ =	30°·05		κ =	299°·30		κ =	67°·71
M_3	R=	·062	P_1	R=	·171	μ_2	R=	·289	$(M_2K_1)_3$	R=	·098
	ζ =	203°·32		ζ =	293°·88		ζ =	296°·82		ζ =	124°·31
	H=	·058		H=	·171		H=	·268		H=	·107
	κ =	224°·72		κ =	11°·16		κ =	85°·34		κ =	300°·80
M_4	R=	·824	J_1	R=	·037	R_2	R=	...	$(2M_2K_1)_3$	R=	·061
	ζ =	101°·28		ζ =	311°·85		ζ =	...		ζ =	334°·46
	H=	·765		H=	·045		H=	...		H=	·065
	κ =	249°·81		κ =	24°·04		κ =	...		κ =	200°·75

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	·088	211°·95	·078	2°·94
„ fortnightly „	·060	265 ·10	·096	33 ·23
Luni-solar „ „	·501	283 ·63	·483	29 ·36
Solar-annual „	1·119	127 ·59	1·119	140 ·31
„ semi-annual „	·182	236 ·91	·182	262 ·35

The mean level of the water (A_0) in 1885-86 is 8·804 feet above the zero of the gauge, which is the lowest value obtained at Diamond Harbour. The mean result is 8·937 feet or about 1½ inches higher.

The mean amplitude (H) of the main lunar tide (M_2) is 5·154 feet, the average value being 5·164 feet. The epoch of this tide is very accordant, being 344°·8, whilst the average is 344°·4.

The mean amplitude (H) of the main solar tide (S_2) is 2·199 feet which is about ¼ of an inch less than the mean of the five years' results, 2·231. It is 0·427 of the main tide, which is very close to the mean value, 0·432; theoretically it ought to be 0·465. The epoch is 25°·98, which is almost identical with the mean value 25°·96 obtained from the five years' observations which are all very accordant.

The luni-solar semi-diurnal tide (K_2) is 0·121 of the main tide and agrees very well both with the theoretical value 0·127 and the average value 0·131. The epoch of this tide is 30°·1, the mean of all the results being 24°·7.

The lunar elliptic tides (L_2 and N_2) are respectively 0·054 and 0·200 of the main tide, values which agree very well with the means 0·050 and 0·185 and not far from the theoretical values 0·028 and 0·194. The epochs of these tides are well established.

The lunar elliptic tide of the 2nd order ($2N_2$) is 0·029 of the main tide, a value which is identical with the mean of all the observations and very near the theoretical proportion, 0·026.

The evectional tides (λ_2 and ν_2) are 0·052 and 0·039 of the main tide. According to theory they should be 0·007 and 0·038; the mean values are 0·028 and 0·054.

The amplitude of the variational tide (μ_2) is 0·052 of the main tide, the mean value is 0·059, and the theoretical value is about half this proportion, or 0·024. The epoch is 85°·34 and the mean of all the determinations which are fairly accordant is 85°·31.

The proportions of the diurnal tides to the main tide are as follow:—

	Diamond Harbour, 1885-86.	Theoretical.
Luni-solar (K_1)	0·100	0·584
Lunar declinational (O_1)	·045	·415
Solar „ (P_1)	·033	·193
„ elliptic (Q_1)	·003	·080
Lunar „ (J_1)	·009	·033
„ (M_1)	·006	·036

These proportions are very low in comparison with the theoretical values, but this has been found to be the case every year at Diamond Harbour and the values *inter se* are very accordant.

With regard to the overtides, the lunar quarter-diurnal (M_4) is the largest, being 0·148 of the main tide which agrees almost exactly with former values and with the mean 0·146. The epoch of this tide is very accordant throughout the observations; this year's value is 249°·8 and the mean of all the results 247°·4.

The proportions of the compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·021
$(MS)_4$	0·138
$(2M_2K_1)_3$	0·013
$(M_2N)_4$	0·023
$(2SM)_2$	0·014

These values are almost identical with the means obtained from all the determinations.

With regard to the long period tides, the lunar monthly is this year 0·015 of the main tide, its mean value being 0·022 and the theoretical 0·046. Its epoch this year is 2°·9, the mean of all the determinations being 9°·6.

The lunar fortnightly tide is 0·019 of the main tide, the mean value derived from all the observations is 0·030, which is considerably less than the theoretical proportion 0·086. The epoch is 33°·2, the mean of all the results being 41°·7.

The luni-solar fortnightly tide is 0·094 of the main tide which accords well with the mean 0·088, but theory gives only 0·007 as its value. Its epoch is 29°·4 which compares well with the average value 34°·4.

The solar-annual tide is 0·217 of the main tide and agrees well with the mean value 0·205. Its epoch is well determined, and this year's value, 140°·3, approaches closely to the mean value, 142°·1.

The solar semi-annual tide has a proportion of 0·035 of the main tide, which is the largest value obtained and approaches the theoretical value, 0·040. The average of all the results is 0·019. Its epoch is very irregular.

Values of the Tidal Constants, Kidderpore, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or fifth year's observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 10{\cdot}950$ feet.

S_1	H = R =	0·088	M_6	R =	0·179	Q_1	R =	0·013	T_2	R =	...
	$\kappa = \zeta$ =	204°·50		ζ =	57°·04		ζ =	52°·86		ζ =	...
S_2	H = R =	1·459		H =	0·161		H =	0·016		H =	...
	$\kappa = \zeta$ =	102°·45		κ =	330°·81		κ =	14°·40		κ =	...
S_4	H = R =	0·074	M_8	R =	0·076	L_2	R =	0·254	$(MS)_4$	R =	0·679
	$\kappa = \zeta$ =	116°·88		ζ =	159°·31		ζ =	55°·64		ζ =	233°·74
S_6	H = R =	0·008		H =	0·065		H =	0·221		H =	0·654
	$\kappa = \zeta$ =	340°·40		κ =	284°·33		κ =	73°·69		κ =	85°·00
S_8	H = R =	0·005	O_1	R =	0·168	N_2	R =	0·701	$(2SM)_2$	R =	0·099
	$\kappa = \zeta$ =	285°·35		ζ =	80°·18		ζ =	176°·96		ζ =	227°·93
				H =	0·209		H =	0·675		H =	0·096
				κ =	22°·86		κ =	47°·08		κ =	16°·67
M_1	R =	0·050	K_1	R =	0·347	ν_2	R =	0·101	$2N_2$	R =	0·103
	ζ =	96°·7		ζ =	147°·36		ζ =	295°·67		ζ =	119°·27
	H =	0·051		H =	0·394		H =	0·098		H =	0·099
	κ =	334°·75		κ =	56°·90		κ =	134°·35		κ =	8°·24
M_2	R =	3·764	K_2	R =	0·285	ν_2	R =	0·332	$(M_2N)_4$	R =	0·047
	ζ =	209°·10		ζ =	95°·73		ζ =	328°·98		ζ =	49°·47
	H =	3·627		H =	0·381		H =	0·320		H =	0·043
	κ =	60°·35		κ =	94°·88		κ =	12°·81		κ =	130°·84
M_3	R =	0·064	P_1	R =	0·132	μ_2	R =	0·222	$(M_2K_1)_3$	R =	0·075
	ζ =	195°·87		ζ =	309°·92		ζ =	128°·96		ζ =	265°·52
	H =	0·060		H =	0·132		H =	0·206		H =	0·082
	κ =	332°·75		κ =	40°·01		κ =	191°·47		κ =	26°·31
M_4	R =	0·792	J_1	R =	0·009	R_2	R =	...	$(2M_2K_1)_3$	R =	0·038
	ζ =	339°·56		ζ =	192°·40		ζ =	...		ζ =	148°·04
	H =	0·736		H =	0·011		H =	...		H =	0·040
	κ =	42°·07		κ =	82°·12		κ =	....		κ =	301°·02

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·304	36°·97	0·269	18°·11
„ fortnightly „	0·199	248·46	0·317	34·36
Luni-solar „ „	1·018	251·57	0·981	40·31
Solar-annual „	3·006	160·80	3·006	160·71
„ semi-annual „	1·307	328·51	1·307	328·33

The mean level of the river (A_0) is 10·950 feet above the zero of the gauge, which is the highest value yet obtained, and 2½ inches in excess of the mean, 10·735, of the whole five years' observations.

The main lunar tide (M_2) has an amplitude of 3·627 feet, which agrees well with former values. Its epoch is 60°·35, the mean being 58°·85.

The amplitude of the main solar tide (S_2) is 1·459 feet. In former years it varied from 1·427 to 1·513. It is 40 per cent. of the main lunar tide. Its epoch is well determined; this year's value is 102°·45 and is almost identical with the mean 102°·28 derived from the five years' observations.

The luni-solar semi-diurnal tide (K_2) is 0·105 of the main tide; the mean of five years' results is 0·123, which is very close to 0·127, the theoretical proportion. The epoch is 94°·88, or about 6½ minutes earlier than last year's value 98°·13 which approaches the average 97°·43.

The two lunar elliptic tides (L_2 and N_2) have proportions to the main tide of 0·061 and 0·186, the theoretical values being 0·028 and 0·194. They accord fairly well with former values.

The lunar elliptic tide of the second order ($2N_2$) is 0·027 of the main tide; it is very close to the theoretical value 0·026, which is also the mean of the five years' determinations.

The evectional tides (λ_2 and ν_2) are 0·027 and 0·088 of the main tide, which are close to the mean values, 0·024 and 0·071, but very much greater than their theoretical proportions, 0·007 and 0·038.

The variational tide (μ_2) is 0·057 of the main tide, which nearly agrees with the mean value, 0·066, but is more than double the theoretical value, 0·024.

The proportions of the diurnal tides to the main tide are as follow :—

		Kidderpore, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·109	0·584
Lunar declinational	(O_1)	0·058	0·415
Solar „	(P_1)	0·036	0·193
„ elliptic	(Q_1)	0·004	0·080
Lunar „	(J_1)	0·003	0·033
„	(M_1)	0·014	0·036

Low values, such as the above, have always been obtained for the diurnal tides at Kidderpore.

The most significant of the overtides is the lunar quarter-diurnal (M_4), the proportion of which to the main tide, 0·203, agrees very well with former values. The next in importance is (M_6) which is 0·044 of the main tide and accordant with all former values. Their epochs are also very well determined.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·180 of the main tide, which agrees very well with the mean value, 0·177. Its epoch is well established; this year it is 85°·0, which is almost identical with last year's value 84°·9, and differs only by 1°·9 from the mean of the five years' determinations.

The proportions of the other compound tides to the main tide are as follow :—

$(M_2K_1)_3$	0·023
$(2M_2K_1)_3$	0·011
$(M_2N)_4$	0·012
$(2SM)_2$	0·026

These values compare very well with previous determinations.

Of the long period tides the lunar monthly is 0·074 of the main tide, the mean value being 0·073 and theoretical 0·046.

The lunar fortnightly tide is 0·087 of the main tide or almost identical with its theoretical value, 0·086, and with the mean value, 0·082.

The luni-solar fortnightly tide is 0·27 of the main tide; by theory it should be 0·007, but the proportion has always been high at this station.

The solar-annual tide is 83 per cent. of the main tide, being the highest value yet obtained and about 11 per cent. above the average.

The solar semi-annual tide is 0·360 of the main tide, or nine times as large as its theoretical value, 0·040. The average of five years is 0·239.

The epochs of the lunar monthly tide are irregular; those of the lunar fortnightly tide show a difference of 19°; those of the luni-solar fortnightly and the solar annual show each a difference of 12° and those of the solar semi-annual continue to be very discordant.

Values of the Tidal Constants, Chittagong, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87, or first year's observations at Chittagong; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations :—

Short Period Tides.

A_0=8·251 feet.

S_1	H=	R=	0·060	M_6	R=	0·158	Q_1	R=	0·014	T_2	R=	...
	κ = ζ =		120°·09		ζ =	140°·18		ζ =	29°·18		ζ =	...
S_2	H=	R=	1·568		H=	0·143		H=	0·016		H=	...
	κ = ζ =		68°·45		κ =	195°·45		κ =	327°·77		κ =	...
S_4	H=	R=	0·049	M_8	R=	0·040	L_2	R=	0·387	$(MS)_4$	R=	0·367
	κ = ζ =		54°·55		ζ =	173°·43		ζ =	351°·10		ζ =	119°·24
S_6	H=	R=	0·010		H=	0·035		H=	0·425		H=	0·355
	κ = ζ =		131°·08		κ =	127°·12		κ =	60°·30		κ =	17°·66
S_8	H=	R=	0·002	O_1	R=	0·246	N_2	R=	0·898	$(2SM)_2$	R=	0·133
	κ = ζ =		217°·41		ζ =	90°·28		ζ =	107°·76		ζ =	197°·83
					H=	0·295		H=	0·869		H=	0·129
					κ =	11°·55		κ =	23°·51		κ =	299°·41

Short Period Tides—contd.

A_0=8·251 feet.

M_1	R=	0·038	K_1	R=	0·523	λ_2	R=	0·214	$2N_2$	R=	0·032
	ζ=	356°·26		ζ=	42°·42		ζ=	224°·31		ζ=	85°·80
	H=	0·025		H=	0·582		H=	0·207		H=	0·031
	κ=	22°·82		κ=	22°·19		κ=	60°·63		κ=	18°·86
M_2	R=	4·575	K_2	R=	0·340	ν_2	R=	0·416	$(M_2N)_4$	R=	0·153
	ζ=	136°·46		ζ=	290°·56		ζ=	243°·71		ζ=	72°·19
	H=	4·428		H=	0·438		H=	0·402		H=	0·143
	κ=	34°·89		κ=	70°·88		κ=	24°·23		κ=	246°·35
M_3	R=	0·041	P_1	R=	0·192	μ_2	R=	0·236	$(M_2K_1)_3$	R=	0·122
	ζ=	10°·51		ζ=	10°·57		ζ=	43°·30		ζ=	72°·13
	H=	0·039		H=	0·192		H=	0·268		H=	0·131
	κ=	218°·15		κ=	26°·00		κ=	200°·14		κ=	310°·32
M_4	R=	0·450	J_1	R=	0·046	R_2	R=	...	$(2M_2K_1)_3$	R=	0·047
	ζ=	185°·12		ζ=	91°·64		ζ=	...		ζ=	85°·89
	H=	0·421		H=	0·053		H=	...		H=	0·049
	κ=	341°·96		κ=	51°·47		κ=	...		κ=	262°·97

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·084	356°·02	0·075	338°·70
„ fortnightly „	0·122	163 ·75	0·181	39 ·64
Luni-solar „ „	0·446	297 ·56	0·432	39 ·14
Solar-annual „	1·666	62 ·02	1·666	136 ·59
„ semi-annual „	0·178	68 ·13	0·178	217 ·27

The mean level of the water (A_0) is 8·251 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow:—

			Chittagong, 1886-87.	Theoretical.
Semi-Diurnal Tides.	Main solar	S_2	0·354	0·465
	Luni-solar	K_2	·099	·127
	Lunar elliptic	N_2	·196	·194
	„ „	L_2	·096	·028
	Evectional	ν_2	·091	·038
	„	λ_2	·047	·007
	Lunar elliptic of the 2nd order	$2N_2$	·007	·026
	Variational	μ_2	·061	·024
Diurnal Tides.	Luni-solar	K_1	·131	·584
	Lunar declinational	O_1	·067	·415
	Solar „	P_1	·043	·193
	„ elliptic	Q_1	·004	·080
	Lunar „	J_1	·012	·033
	„	M_1	·006	·036
	Solar	S_1	·014	...
Over Tides	Lunar	M_3	·009	·013
	„	M_4	·095	...
	„	M_6	·032	...
	„	M_8	·008	...
	Solar	S_4	·011	...
	„	S_6	·002	...
	„	S_8	·000	...
Compound Tides.	Ter-diurnal	$(M_2K_1)_3$	·030	·121
	Quarter-diurnal	$(MS)_4$	·080	·096
	Ter-diurnal	$(2M_2K_1)_3$	·011	·086
	Quarter-diurnal	$(M_2N)_4$	·032	·040
	Semi-diurnal	$(2SM)_2$	·029	...
Long Period Tides.	Lunar monthly	.	·017	·046
	„ fortnightly	.	·041	·086
	Luni-solar „	.	·098	·007
	Solar-annual	.	·376	...
	„ semi-annual	.	·040	·040

VALUES OF THE TIDAL CONSTANTS, ELEPHANT POINT, 1885.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885, or 2nd year's observations at the new site at Elephant Point; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885 observations :—

Short Period Tides.

A_0 = 11·745 feet.

S_1	H = R =	0·082	M_6	R =	0·270	Q_1	R =	0·019	T_2	R =	0·318
	κ = ζ =	126°·48		ζ =	330°·33		ζ =	173°·03		ζ =	92°·74
S_2	H = R =	2·397		H =	0·241		H =	0·024		H =	0·318
	κ = ζ =	140°·08		κ =	337°·74		κ =	328°·93		κ =	92°·67
S_4	H = R =	0·088	M_8	R =	0·117	L_2	R =	0·292	$(MS)_4$	R =	0·307
	κ = ζ =	176°·94		ζ =	324°·04		ζ =	289°·58		ζ =	125°·26
S_6	H = R =	0·007		H =	0·101		H =	0·250		H =	0·296
	κ = ζ =	262°·46		κ =	333°·93		κ =	131°·54		κ =	127°·73
S_8	H = R =	0·005	O_1	R =	0·261	N_2	R =	1·091	$(2SM)_2$	R =	0·112
	κ = ζ =	284°·04		ζ =	196°·80		ζ =	98°·81		ζ =	37°·04
				H =	0·323		H =	1·052		H =	0·112
				κ =	8°·36		κ =	85°·62		κ =	34°·57
M_1	R =	0·008	K_1	R =	0·650	λ_2	R =	0·184	$2N_2$	R =	0·213
	ζ =	276°·58		ζ =	188°·45		ζ =	340°·15		ζ =	113°·80
	H =	0·009		H =	0·737		H =	0·178		H =	0·205
	κ =	125°·30		κ =	19°·47		κ =	144°·48		κ =	84°·96
M_2	R =	6·113	K_2	R =	0·536	ν_2	R =	0·142	$(M_2N_2)_4$	R =	0·213
	ζ =	101°·48		ζ =	293°·11		ζ =	101°·49		ζ =	55°·46
	H =	5·890		H =	0·716		H =	0·137		H =	0·198
	κ =	103°·95		κ =	135°·16		κ =	122°·10		κ =	44°·75
M_3	R =	0·028	P_1	R =	0·189	μ_2	R =	0·421	$(M_2K_1)_3$	R =	0·050
	ζ =	153°·72		ζ =	222°·63		ζ =	288°·52		ζ =	150°·76
	H =	0·026		H =	0·189		H =	0·391		H =	0·055
	κ =	337°·43		κ =	31°·59		κ =	293°·47		κ =	344°·26
M_4	R =	0·312	J_1	R =	0·053	R_2	R =	0·077	$(2M_2K_1)_3$	R =	0·072
	ζ =	82°·80		ζ =	256°·25		ζ =	284°·00		ζ =	179°·11
	H =	0·289		H =	0·064		H =	0·077		H =	0·076
	κ =	87°·74		κ =	102°·82		κ =	104°·07		κ =	353°·03

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide . . .	0·136	351°·30	0·120	6°·96
„ fortnightly „ . . .	0·075	184 ·93	0·120	24 ·28
Luni-solar „ „ . . .	0·254	55 ·25	0·245	52 ·78
Solar-annual „ . . .	0·873	220 ·03	0·873	141 ·07
„ semi-annual „ . . .	0·107	17 ·18	0·107	219 ·26

The mean level of the water (A_0) is 11·745 feet above the present zero of the gauge, which is 3·896 feet higher than the zero to which the heights were referred in 1884. The mean level of the water for that year was 12·418 feet above the present zero, or 16·314 feet above the original zero, thus there is a difference of 0·673 foot between the two years' determinations.

The main lunar tide (M_2) has an amplitude of 5·890 feet; in 1884 it was 5·876 feet. The epoch is also accordant, being 103°·95 against 101°·88.

The mean amplitude (H), 2·397 feet, of the main solar tide (S_2) agrees well with the previous year's value, 2·384; the epoch is also very accordant, this year's value being 140°·1 and that obtained in the previous year 139°·6. Its proportion to the main lunar tide 0·407, is almost identical with that in the preceding year; the theoretical proportion is 0·465.

The luni-solar semi-diurnal tide (K_2) is 0·122 of the main tide, or nearly the theoretical value, 0·127. Its epoch is about half an hour later than it was last year.

The amplitude of the smaller lunar elliptic tide (ν_2) is 0·042 of the main tide, the theoretical value is 0·028, and that found in 1884, 0·075. The larger component (N_2) is nearer the value assigned by theory, being 0·179 against 0·194. In the previous year it was 0·164.

The lunar elliptic tide of the second order ($2N_2$) is 0·035 of the main tide, instead of 0·026, the theoretical value. In 1884 it was 0·048.

The two solar elliptic tides (R_2 and T_2) have been evaluated from the 1884 and 1885 observations for the first time. Their amplitudes are 0·013 and 0·054 of the main tide.

The evectional tides (λ_2 and ν_2) are 0·030 and 0·023 of the main tide, and agree well with the 1884 values. Theoretically they should be 0·007 and 0·038. The variational tide (μ_2) is 0·066 of the main tide, or nearly three times as large as the theoretical value 0·024. In 1884 it was 0·059.

The proportions of the diurnal tides to the main tide are as follow:—

		Elephant Point, 1885.	Theoretical.
Luni-solar	(K_1)	0·125	0·584
Lunar declinational	(O_1)	0·055	0·415
Solar „	(P_1)	0·032	0·193
„ elliptic	(Q_1)	0·004	0·080
Lunar „	(J_1)	0·011	0·033
„	(M_1)	0·002	0·036

Similar low values were obtained in 1884 for these tides.

Of the overtides the lunar quarter-diurnal (M_4) and the sexter-diurnal (M_6) are 0·049 and 0·041 of the main tide, which accord well with the 1884 values. The epochs are also very close to the 1884 values.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·050 against 0·053 in the previous year. The epoch is this year 6 minutes later.

The proportions of the other compound tides to the main tide are as follow: —

$(M_2K_1)_3$	0·009
$(2M_2K_1)_3$	0·013
$(M_2N)_4$	0·034
$(2SM)_2$	0·019

With the exception of $(MS)_4$ the quarter-diurnal $(M_2N)_4$ is the largest, being nearly $3\frac{1}{2}$ per cent. of the main tide.

Regarding the long period tides, the lunar monthly is 0·020 of the main tide, which is also last year's value; but theoretically it should be 0·046.

The lunar fortnightly tide, which also is 0·020 of the main tide, is even more divergent from the theoretical proportion, 0·086. Last year the proportion was 0·032.

The luni-solar fortnightly tide is 0·042 of the main tide, instead of 0·007 according to theory. In the preceding year it was nearly the same, being 0·038. The epoch so far is very accordant.

The solar-annual tide is 0·148 of the main tide, or just 1 per cent. higher than the value for 1884. Its epoch is divergent from last year's value, being 24 days later.

The solar semi-annual tide is 0·018 of the main tide, or nearly half the theoretical value, 0·040; but it agrees closely with the value, 0·023, obtained in 1884. Its epoch is about 8 days later than it was last year.

Values of the Tidal Constants, Amherst, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85, or fifth year's observations at Amherst; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=13·588 feet.

S_1	H = R =	0·137	M_6	R =	0·158	Q_1	R =	0·016	T_2	R =	...
	$\kappa = \zeta$ =	132°·64		ζ =	143°·26		ζ =	246°·89		ζ =	...
S_2	H = R =	2·700		H =	0·142		H =	0·020		H =	...
	$\kappa = \zeta$ =	95°·11		κ =	250°·34		κ =	7°·37		κ =	...
S_4	H = R =	0·099	M_8	R =	0·024	L_2	R =	0·444	$(MS)_4$	R =	0·311
	$\kappa = \zeta$ =	101°·27		ζ =	79°·42		ζ =	5°·20		ζ =	29°·86
S_6	H = R =	0·002		H =	0·021		H =	0·373		H =	0·300
	$\kappa = \zeta$ =	164°·48		κ =	222°·19		κ =	89°·84		κ =	65°·55
S_8	H = R =	0·002	O_1	R =	0·271	N_2	R =	1·238	$(2SM)_2$	R =	0·188
	$\kappa = \zeta$ =	266°·99		ζ =	357°·92		ζ =	243°·73		ζ =	49°·13
				H =	0·335		H =	1·194		H =	0·181
				κ =	347°·32		κ =	50°·50		κ =	13°·44

Short Period Tides—contd.

A_0=13·588 feet.

M_1	R=	0·031	K_1	R=	0·620	λ_2	R=	0·184	$2N_2$	R=	0·212
	ζ=	254°·93		ζ=	316°·02		ζ=	181°·48		ζ=	134°·48
	H=	0·038		H=	0·702		H=	0·178		H=	0·204
	κ=	92°·93		κ=	1°·12		κ=	132°·83		κ=	72°·32
M_2	R=	6·668	K_2	R=	0·729	ν_2	R=	0·241	$(M_2N)_4$	R=	0·213
	ζ=	29°·39		ζ=	186°·37		ζ=	85°·37		ζ=	41°·37
	H=	6·427		H=	0·973		H=	0·232		H=	0·198
	κ=	65°·09		κ=	96°·40		κ=	25°·41		κ=	243°·84
M_3	R=	0·034	P_1	R=	0·195	μ_2	R=	0·218	$(M_2K_1)_3$	R=	0·093
	ζ=	3°·78		ζ=	49°·79		ζ=	209°·75		ζ=	220°·85
	H=	0·033		H=	0·195		H=	0·202		H=	0·102
	κ=	237°·32		κ=	5°·61		κ=	281°·43		κ=	301°·65
M_4	R=	0·339	J_1	R=	0·023	R_2	R=	...	$(2M_2K_1)_3$	R=	0·042
	ζ=	324°·34		ζ=	143°·38		ζ=	...		ζ=	293°·57
	H=	0·315		H=	0·028		H=	...		H=	0·044
	κ=	35°·73		κ=	58°·60		κ=	...		κ=	319°·85

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·055	134°·59	0·049	3°·52
„ fortnightly „	0·067	156 ·79	0·107	33 ·68
Luni-solar „ „	0·069	105 ·00	0·067	69 ·31
Solar-annual „	0·713	12 ·37	0·713	146 ·54
„ semi-annual „	0·119	272 ·39	0·119	180 ·74

The mean level of the water (A_0) in 1884-85 is 13·588 feet above the zero of the gauge, which is the lowest value yet obtained.

The amplitude of the main lunar tide (M_2) is 6·427 feet which is higher than its value in former years. The epoch is 65°·09, or 2 minutes earlier than last year.

The main solar tide (S_2) is 2·700 feet in amplitude. In proportion to the main tide it is 0·420 or 4½ per cent. less than the theoretical value, 0·465. Last year it was also 0·420 of the main tide, and in former years it was slightly higher, but in no instance has it reached the theoretical proportion. The epoch is about 10 minutes earlier than last year.

The luni-solar semi-diurnal tide (K_2) is 0·151 of the main tide, or 2 per cent. greater than the theoretical value 0·127. The epoch is 96°·40, or nearly the same as it was in 1882-83.

Of the lunar elliptic tides, the smaller component (L_2) is 0·058 of the main tide, or twice as large as the theoretical value, 0·028; whilst the larger component (N_2) approaches the theoretical value, 0·194, being 0·186 of the main tide. These proportions agree very well with the values obtained in former years.

The lunar elliptic tide of the second order (2 N_2) is 0·032 of the main tide, or somewhat in excess of the theoretical value, 0·026.

The proportions of the two evectional tides (λ_2 and ν_2) are 0·028 and 0·036 of the main tide. According to theory they should be 0·007 and 0·038.

The variational tide (μ_2) is 0·031 against 0·024, the theoretical proportion. In the preceding year it was somewhat higher.

The proportions of the diurnal tides to the main tide are as follow:—

	Amherst, 1884-85.	Theoretical.
Luni-solar (K_1)	0·109	0·584
Lunar declinational (O_1)	0·052	0·415
Solar „ (P_1)	0·030	0·193
„ elliptic (Q_1)	0·003	0·080
Lunar „ (J_1)	0·004	0·033
„ (M_1)	0·005	0·036

Every year these tides have been found to be very much less than they should be by theory.

As regards the overtides, the lunar quarter-diurnal (M_4) and sexter-diurnal (M_6) are the largest, being 0·049 and 0·022 of the main tide, which are very near the former values; their epochs also agree very well with the previous determinations.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·047 of the main tide and is very close to the proportions obtained in former years. The epoch of this tide is again earlier than its preceding value.

The amplitudes of the other compound tides in proportion to the main tide are as follow :—

$(M_2K_1)_3$	0·016
$(2M_2K_1)_3$	0·007
$(M_2N)_4$	0·031
$(2SM)_{2^*}$	0·028

These values are very accordant with former results.

With regard to the long period tides, the lunar monthly is 0·008 of the main tide or about $\frac{1}{8}$ the theoretical value, 0·046; but this tide has always been small at this station. Its epoch is variable.

The lunar fortnightly tide is 0·017 of the main tide, theoretically it should be 0·086, but this tide also has always been found to be far below its theoretical value. Its epoch also is variable.

The luni-solar fortnightly tide is 0·010 of the main tide and is very accordant with last year's value, 0·008, and the theoretical value, 0·007. The epoch of this tide is also very irregular.

The solar-annual tide is 0·111 of the main tide. It is very accordant with the results obtained in former years. The epoch, 146°·54, agrees well with former values, with the exception of that obtained in 1882-83, which was 17 days earlier.

The solar semi-annual tide is 0·019 of the main tide. Theoretically it should be 0·040. The epoch of this tide also has always been irregular.

Values of the Tidal Constants, Amherst, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86, or sixth and final year's observations at Amherst; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=13·311 feet.

S_1	H = R =	0·131	M_6	R =	0·169	Q_1	R =	0·028	T_2	R =	0·352
	κ = ζ =	121°·86		ζ =	201°·77		ζ =	209°·69		ζ =	291°·51
S_2	H = R =	2·563		H =	0·151		H =	0·035		H =	0·352
	κ = ζ =	102°·09		κ =	248°·96		κ =	347°·19		κ =	78°·55
S_4	H = R =	0·075	M_8	R =	0·026	L_2	R =	0·342	$(MS)_4$	R =	0·285
	κ = ζ =	107°·59		ζ =	56°·97		ζ =	156°·57		ζ =	288°·41
S_6	H = R =	0·002		H =	0·023		H =	0·314		H =	0·275
	κ = ζ =	341°·57		κ =	239°·89		κ =	78°·07		κ =	64°·14
S_8	H = R =	0·003	O_1	R =	0·252	N_2	R =	1·360	$(2SM)_2$	R =	0·182
	κ = ζ =	244°·36		ζ =	254°·16		ζ =	229°·57		ζ =	103°·64
				H =	0·310		H =	1·312		H =	0·176
				κ =	349°·30		κ =	47°·65		κ =	327°·91
M_1	R =	0·052	K_1	R =	0·653	λ_2	R =	0·224	$2N_2$	R =	0·179
	ζ =	266°·02		ζ =	321°·95		ζ =	322°·06		ζ =	200°·68
	H =	0·045		H =	0·738		H =	0·216		H =	0·173
	κ =	28°·99		κ =	3°·88		κ =	183°·97		κ =	61°·11
M_2	R =	6·652	K_2	R =	0·566	ν_2	R =	0·102	$(M_2N)_4$	R =	0·038
	ζ =	291°·53		ζ =	207°·25		ζ =	185°·51		ζ =	205°·64
	H =	6·415		H =	0·752		H =	0·099		H =	0·035
	κ =	67°·26		κ =	111°·49		κ =	55°·06		κ =	159°·45
M_3	R =	0·033	P_1	R =	0·212	μ_2	R =	0·350	$(M_2K_1)_3$	R =	0·112
	ζ =	56°·21		ζ =	56°·20		ζ =	21°·44		ζ =	170°·29
	H =	0·031		H =	0·212		H =	0·326		H =	0·122
	κ =	259°·81		κ =	12°·27		κ =	292°·90		κ =	347°·95
M_4	R =	0·293	J_1	R =	0·037	R_2	R =	0·174	$(2M_2K_1)_3$	R =	0·035
	ζ =	120°·57		ζ =	74°·27		ζ =	283°·28		ζ =	83°·60
	H =	0·273		H =	0·045		H =	0·174		H =	0·037
	κ =	32°·03		κ =	72°·50		κ =	316°·23		κ =	313°·14

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·007	332°·57	0·006	290°·22
„ fortnightly „	0·011	87 ·37	0 017	212 ·82
Luni-solar „ „	0·071	81 ·98	0·068	306 ·24
Solar-annual „	0·886	332 ·61	0·886	106 ·54
„ semi-annual „	0·154	246 ·04	0·154	153 ·91

The value of the mean level of the water (A_0) as determined from this the final year's observations is 13·311 feet above the zero of the gauge. This is the lowest value at Amherst and the difference between it and the mean of the six years' results, 13·654, is about 4 inches. The highest value obtained in 1881-82 was 13·974.

The amplitude of the main lunar tide (M_2) is 6·415 feet which is very close to the highest value, 6·427 feet, obtained in 1884-85. The mean value is 6·320 feet or about an inch smaller. The epoch is very well determined, all the six years' values being very accordant; the mean value is 67°·4.

The main solar tide (S_2) is 0·400 of the main tide and is the smallest proportion obtained at this station for this tide; the mean value, 0·429, is 3½ per cent. less than the theoretical value, 0·465. The epoch is 102°·09 which agrees almost exactly with the mean value, 102°·03.

The luni-solar semi-diurnal tide (K_2) is 0·117 of the main tide; the mean value is 0·156 and the theoretical, 0·127. The epoch 111°·49 is the largest obtained, being 15° greater than last year's value which was almost identical with the mean, 96°·35.

Of the two lunar elliptic tides (L_2 and N_2) the smaller component (L_2) is 0·049 of the main tide, or nearly double the theoretical value; whilst the larger (N_2) is 0·205 or very close to the theoretical value, 0·194. The values have always been accordant and their means are 0·051 and 0·203 respectively. Their epochs are somewhat early this year.

The lunar elliptic tide of the second order ($2N_2$) is 0·027 of the main tide which is almost identical with the theoretical value 0·026. The values have been decreasing from the first year's value which was 0·052. The mean value is 0·039. The epoch is not at all regular.

The solar elliptic tides (R_2 and T_2) are 0·027 and 0·055 respectively of the main tide, the mean values being 0·035 and 0·068.

The proportions of the two evectional tides (λ_2 and ν_2) are 0034 and 0·015 respectively of the main tide. The mean values are 0·039 and 0·054 and the theoretical 0·007 and 0·038. The epoch of λ_2 is variable, but that of ν_2 is fairly regular.

The variational tide (μ_2) is 0·051 of the main tide. This tide has fluctuated from 0·031 to 0·071; the mean value is 0·045 or nearly double the theoretical proportion, 0·024.

The proportions of the diurnal tides to the main tide are as follow:—

		Amherst, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·115	0·584
Lunar declinational	(O_1)	·048	·415
Solar „	(P_1)	·033	·193
„ elliptic	(Q_1)	·005	·080
Lunar „	(J_1)	·007	·033
„	(M_1)	·007	·036

Thus it will be seen that the diurnal tides again have very small values in proportion to the main tide and the results are very accordant with all the former values.

With regard to the overtides, the lunar quarter-diurnal (M_4) is 0·043 of the main tide, which does not differ much from the mean, 0·052, and the sexter-diurnal (M_6) is 0·024 of the main tide which agrees very well with the mean, 0·021. The amplitudes of both these tides agree well with former values. The epochs of (M_4) show a gradual diminution year by year from 60°·3 to 32°·0 in 1885-86, and the epoch of (M_6) is well determined. The remaining overtides are as usual insignificant.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·043 of the main tide—a proportion which agrees well with former values, and the mean is 0·051. Its epoch has become earlier every year; in 1880-81 it was 90°·0 and this year it is 64°·1.

The proportions of the other compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·019
$(2M_2K_1)_3$	·006
$(M_2N)_4$	·005
$(2SM)_2$	·027

Throughout the observations at this station the compound tides with the exception of $(M_2N)_4$ have been very accordant *inter se*. The proportion of $(M_2N)_4$ to the main tide has varied between 0·053 in 1881-82 and 0·005 in 1885-86.

Regarding the long period tides, the lunar monthly is only 0·001 of the main tide instead of 0·046, the theoretical proportion, below which it has always remained. The mean value is 0·011. Its epoch is variable.

The lunar fortnightly tide is also insignificant in its proportion to the main tide, being only 0·003 instead of 0·086, the theoretical value, and the mean value is 0·013. Its epoch, also is irregular.

The luni-solar fortnightly tide is 0·011 of the main tide; the mean value 0·009 is almost the same as the theoretical value, 0·007. Its epoch also is very irregular.

The solar-annual tide is 0·138 of the main tide, the average being 0·119. Its epoch, 106°·5, is unusually early this year and does not accord well with the mean value, 136°·4.

The solar semi-annual tide is 0·024 of the main tide which agrees exactly with the mean of all the determinations, but is less than the theoretical value, 0·040. The epoch of this tide has not been well established.

Values of the Tidal Constants, Moulmein, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86, or sixth and final year's observations at Moulmein; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=8·388 feet.

S_1	H=		M_6	R=	0·093	Q_1	R=	0·037	T_2	R=	0·264
	R=	0·074		ζ =	44°·71		ζ =	13°·70		ζ =	204°·76
	κ =	154°·09		H=	0·084		H=	0·046		H=	0·264
S_2	H=	1·364		κ =	218°·47		κ =	57°·33		κ =	100°·22
	R=	1·364	M_8	R=	0·042	L_2	R=	0·338	$(MS)_4$	R=	0·742
	κ =	151°·41		ζ =	11°·34		ζ =	59°·56		ζ =	280°·05
S_4	H=	0·073		H=	0·036		H=	0·297		H=	0·715
	R=	0·073		κ =	123°·01		κ =	144°·17		κ =	217°·96
	κ =	228°·02	O_1	R=	0·198	N_2	R=	0·739	$(2SM)_2$	R=	0·123
S_6	H=	0·007		ζ =	49°·46		ζ =	122°·03		ζ =	338°·22
	R=	0·007		H=	0·245		H=	0·713		H=	0·118
	κ =	222°·05		κ =	53°·58		κ =	99°·45		κ =	40°·30
S_8	H=	0·000	K_1	R=	0·378	λ_2	R=	0·171	$2N_2$	R=	0·125
	R=	0·000		ζ =	107°·71		ζ =	311°·04		ζ =	56°·63
	κ =	198°·44		H=	0·429		H=	0·165		H=	0·120
M_1	R=	0·026		κ =	42°·60		κ =	170°·32		κ =	73°·56
	ζ =	59°·22	K_2	R=	0·231	ν_2	R=	0·344	$(M_2N)_4$	R=	0·093
	H=	0·026		ζ =	108°·74		ζ =	247°·70		ζ =	88°·90
	κ =	71°·65		H=	0·309		H=	0·331		H=	0·086
M_2	R=	3·946		κ =	158°·63		κ =	84°·25		κ =	4°·24
	ζ =	177°·33	P_1	R=	0·116	μ_2	R=	0·366	$(M_2K_1)_3$	R=	0·122
	H=	3·803		ζ =	349°·93		ζ =	43°·24		ζ =	214°·60
	κ =	115°·25		H=	0·116		H=	0·339		H=	0·133
M_3	R=	0·030		κ =	54°·42		κ =	279°·08		κ =	87°·40
	ζ =	135°·14	J_1	R=	0·012	R_2	R=	0·204	$(2M_2K_1)_3$	R=	0·105
	H=	0·028		ζ =	177°·63		ζ =	147°·04		ζ =	119°·96
	κ =	42°·02		H=	0·015		H=	0·204		H=	0·111
M_4	R=	0·965		κ =	71°·92		κ =	71°·57		κ =	60°·91
	ζ =	300°·18									
	H=	0·897									
	κ =	176°·01									

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide . . .	0·417	41°·83	0·369	9°·33
„ fortnightly „ . . .	0·233	282 ·38	0·371	32 ·04
Luni-solar „ „ . . .	1·103	343 ·21	1·063	45 ·30
Solar-annual „ . . .	2·128	125 ·19	2·128	150 ·71
„ semi-annual „ . . .	0·730	236 ·78	0·730	287 ·80

The mean level of the water (A_0) is 8·388 feet above the zero of the gauge. The average of six years is 8·507 feet.

The amplitude of the main lunar tide (M_2) is 3·803 feet, which agrees well with former values. The mean is 3·791 feet. Its epoch is well established, the average being 113°·6.

The main solar tide (S_2) is 1·364 feet in amplitude and is very accordant with former values and with the mean, 1·361. In its proportion to the main lunar tide it is only 0·359 instead of the theoretical value, 0·465. The epoch, 151°·4, is also very close to the former values and is slightly in excess of the mean, 149°·1.

The amplitude of the luni-solar semi-diurnal tide (K_2) is 0·309 of a foot, which is fairly accordant with previous values and with the mean, 0·327. Its proportion to the main tide is 0·081, the mean value being 0·086 and the theoretical, 0·127. Its epoch is well determined, its present year's value is 158°·6 and the mean 157°·6.

The smaller lunar elliptic tide (L_2) is 0·078 of the main tide, which is almost identical with the mean value, 0·079. The theoretical value is 0·028. The larger component (N_2) is 0·187, which closely approaches the theoretical value, 0·194. The average of six years' values is 0·177.

The lunar elliptic tide of the second order ($2N_2$) is 0·032, which is slightly in excess of the mean value, 0·025, and the theoretical value, 0·026.

The solar elliptic tides (R_2 and T_2) have been computed from the 1884-85 and 1885-86 observations. The smaller component (R_2) is 0·054 and the larger (T_2) is 0·069 of the main tide. The mean values are 0·039 and 0·055 respectively.

The two evectional tides (λ_2 and ν_2) are 0·043 and 0·087 of the main tide. They agree very well with the mean values, 0·043 and 0·072; but are very much higher than their theoretical values, 0·007 and 0·038, respectively.

The variational tide (μ_2) is 0·089 of the main tide. Theoretically it is only 0·024; but its values have always been very accordant, the average of the six years' determinations is 0·085.

The proportions of the diurnal tides to the main tide are as follow:—

		Moulmein, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·113	0·584
Lunar declinational	(O_1)	0·064	0·415
Solar „	(P_1)	0·031	0·193
„ elliptic	(Q_1)	0·012	0·080
Lunar „	(J_1)	0·004	0·033
„	(M_1)	0·007	0·036

These tides have always had very small values and have been very accordant *inter se.*

Of the overtides, the lunar quarter-diurnal (M_4) is the most significant, being 23½ per cent. of the main tide. This proportion has been always obtained here. Its epoch is very well determined, this year's value is 176°·0 and the mean 172°·1.

The luni-solar quarter-diurnal tide ($MS)_4$ is 0·188 of the main tide, which is very close to the average value, 0·187. Its epoch is 218°·0, which accords well with former values and with the mean 213°·3.

The proportions of the other compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·035
$(2M_2K_1)_3$	0·029
$(M_2N)_4$	0·023
$(2SM)_2$	0·031

They agree well with all the values previously obtained.

The lunar monthly tide is 0·097 of the main tide, which is identical with the mean of the six years' determinations, but double the theoretical value 0·046. Its epoch is 9°·3, whilst the mean of the six years is 12°·5, but the values obtained during these years are rather variable.

The lunar fortnightly tide is 0·098 of the main tide, which is only slightly in excess of the mean value, 0·087, and the theoretical, 0·086. There has always been a fair agreement between the values of this tide; and its epoch is well determined.

The luni-solar fortnightly tide is 0·280 of the main tide, which agrees well with former values and with the mean value, 0·288; but theoretically it should only be 0·007. The epoch of this tide is well established, the mean value being 45°·0.

The solar-annual tide is 0·560 of the main tide, which is 5½ per cent. lower than the mean value, 0·615. The several years' values are not very accordant, but the epoch is well determined, its mean value being 148°·7.

The solar semi-annual tide is 0·192 of the main tide, which is much in excess of the theoretical value, 0·040; but this has always been found to be the case at Moulmein. Its epoch is fairly well determined, the mean value being 285°·9.

Memorandum by MAJOR A. W. BAIRD, R.E., F.R.S., *Deputy Superintendent, Survey of India, regarding certain tidal disturbances at the Head of the Bay of Bengal on the 11th March and 9th April 1885.*

The diagrams of the self-registering tide gauges at False Point and Dublat (Saugor Island), and at Diamond Harbour and Kidderpore (on the Hooghly), for the 11th March and 9th April 1885 shew unmistakably that considerable tidal disturbances took place on those dates at the stations named.

There are no irregularities to be found on the tidal diagrams at Port Blair for the dates specified; and as the depression or negative wave on the morning of the 11th March was of considerable magnitude (over 1 foot) and the elevation or positive wave on the night of the 8th or early morning of the 9th April was also very considerable, it would appear that the cause of the disturbance took place in the vicinity of False Point and Dublat.

Unfortunately there is no record of tidal registration at Vizagapatam on the above dates, as the observatory was removed to be set up at Cocanada after the completion of five years' work.

With regard to the disturbance of March 11th, it is evident that its effect was slightly felt at Dublat about 10-30 P.M. on the 10th March when it was almost low-water, and

these slight disturbances continued all through the next rising tide, although they are not very marked; but about the time of high-water, a very considerable depression, amounting to at least 1·3 foot, occurred at 7-15 A.M. of the 11th March.

At Diamond Harbour the disturbance is only apparent by the very marked depression at 9-20 A.M. of the 11th March, and although the tidal curve on the afternoon of the 11th is obviously irregular, the tidal disturbances are not distinguishable as they are marked in the quick-rising normal tide.

At Kidderpore the effect of the disturbance is slightly apparent at 4-30 A.M. of the 11th, and again about 9-20 A.M., but the principal disturbance is seen at 0-15 P.M. of the 11th.

At False Point the tidal disturbance seems to have commenced at the low-water on the night of the 10th March, but the first marked feature is the great depression or negative wave at 5-30 A.M. of the 11th March; in magnitude it was about 1·2 feet.

Tabulating the time of arrival (in Calcutta time) of the lowest point of this depression we find it reached—

False-Point at 5-36 A.M., 11th March,
Dublat at 7-15 A.M., 11th March,
Diamond-Harbour at 9-20 A.M., 11th March,
Kidderpore at 0-10 P.M., 11th March.

The speed of this wave up the Hooghly was thus 2 hours and 5 minutes for the 38 miles between Dublat and Diamond Harbour, and 2 hours 50 minutes for the 42 miles between Diamond Harbour and Kidderpore.

The depression decreased in magnitude as it passed up the Hooghly from 16 inches nearly at Dublat to about 11 inches at Diamond Harbour, while at Kidderpore it was only about 2 or 2½ inches.

The magnitude of the depression at False Point and Dublat appears to be about the same, *viz.*, from 15 to 16 inches.

With regard to the tidal disturbances of the 9th April at Dublat the effect is first seen about 10-15 A.M. on the 8th April, but the principal feature is the very large rise—about 16 inches—at 11-50 P.M., and this followed by a fall of nearly the same magnitude about 1 A.M. of the 9th April.

At Diamond Harbour the disturbance is very marked at the low-water of the early morning of the 9th: the first great wave, equal to 2 feet in magnitude, reached Diamond Harbour at 1-30 A.M. of the 9th April.

The tidal disturbances at Kidderpore of the 9th April are almost precisely similar to those at Diamond Harbour; the crest of the first great wave reached Kidderpore at 4-5 A.M., and its magnitude was also about 2 feet.

It is very remarkable that this wave apparently increased in magnitude from Dublat to Diamond Harbour and did not decrease from Diamond Harbour to Kidderpore.

The tidal station at Dublat is on the east side of Saugor Island about 4 miles from the sea face: it seems reasonable to suppose that as the wave was greater at Diamond Harbour than at Dublat, it was generated either very much nearer Diamond Harbour than Dublat, or else that its direction of advance was straight up the Hooghly to Diamond Harbour.

The disturbance of the 9th April at False Point would appear to have commenced about 3 P.M. of the 8th and to have continued for at least 24 hours, the marked feature however is the wave at 11-55 P.M. [0-1 A.M., 9th, Calcutta time]; although its height was only some 3 or 4 inches, this wave obviously corresponds to that which arrived about the same time at Dublat—

The great wave arrived at False Point at 0-1 A.M., 9th April (Calcutta time).

Dublat	at 11-55 P.M., 8th	„	„
Diamond Harbour	at 1-30 A.M., 9th	„	„
Kidderpore	at 4-5 A.M., 9th	„	„

Thus the speed of the wave was 1 hour 35 minutes for the 38 miles between Dublat and Diamond Harbour, while it took 2 hours and 35 minutes to travel from Diamond Harbour to Kidderpore.

Comparing the speeds up the Hooghly of the waves of the 11th March and 9th April with that of the first great wave caused by the Krakatoa eruption, we find—

Negative wave of 11th March took	2 hours & 5 minutes	for 38 miles from Dublat to Diamond Harbour.
Positive „ 9th April .	1 „ & 35 „	
„ for Krakatoa .	2 „ & 9 „	
Negative wave of 11th March took	2 hours 50 minutes	for 42 miles from Diamond Harbour to Kidderpore.
Positive „ 9th April „	2 „ 35 „	
„ Krakatoa . .	1 „ 55 „	

It is peculiar that the positive wave of the 9th April should have travelled much more quickly from Dublat to Diamond Harbour than the Krakatoa wave did, while from Diamond Harbour to Kidderpore the reverse was the case.

In the absence of information from a third station on the Bay of Bengal it is useless to attempt any elaborate calculations to determine the probable *locus* of the disturbance.

It would appear however as if a submarine depression caused the tidal disturbance of the 11th March, and that this was followed about a month later, *viz.*, the 9th April, by a submarine upheaval which caused a very considerable wave to pass up the Hooghly.

The chart of the soundings from the mouth of the Hooghly to False Point shew the depth of the water to be from 25 to 40 fathoms, and applying the table in "Airy's Tides and Waves, Encyclo. Met." it may be assumed that as the depression of the 11th March reached False Point about 1 hour and 40 minutes sooner than Dublat, that the *locus* of disturbance was about 80 miles nearer False Point than Dublat: whereas the positive wave of the 9th April having reached False Point and Dublat almost simultaneously, the *locus* of the disturbance might be supposed equally distant from both those places.

Taking the above into consideration with the fact of the very great wave at Diamond Harbour, while at Dublat it was less, it would almost seem as if the sub-marine upheaval took place at the Sand Heads opposite Balasore.

Upper Burma.

Extract from the Narrative Report of Major J. R. Hobday *on the Survey Operations in the* Northern Shan States, *&c.—Season 1886-87.*

On the 7th November, I started with an expedition under Colonel Stedman to Thonzé in the Shan States, marching the first day to Tongbo. The following day we marched to Zibingalé, up a steep ascent to the Shan plateau, which has an elevation of 2,100 feet. It rained the whole way, and on arrival we found nearly the entire garrison, 190 odd out of a total of 200 including the commanding and medical officers, struck down with fever. It rained almost continuously for the four following days, compelling us to halt. On the 13th we continued our march to Sengaung, elevation 3,000 feet, and halted again on the 14th and 15th. On the 16th November we arrived at Pyin-ul-win, elevation 3,600 feet, where there is an open expanse on which now stands our most advanced post eastward from Mandalay. The minimum thermometer recorded 50° Fahr. at night. On the 17th we marched to Nyaungthakaw, elevation 3,500 feet, minimum thermometer recorded 45°. On the 18th we arrived at our destination, Thonzé, descending to an elevation of 2,000 feet. Here we found that the individual holding the place in the Myinzain's interest, by name Hein Se, had decamped to the neighbouring State of Mainlon. The town was strongly defended with stockades and outworks, moreover the river with its canals afforded additional strength. The whole position is surrounded with dense jungle, and one of the Goorkhas and a *khalási* of mine ran foul of some *panjis*, or bamboo spikes, which we afterwards found were widely scattered round the place, hidden in the grass. From the 19th to the 22nd I spent on my back, with as severe an attack of fever as Burma can produce and of which I had reminding recurrences at intervals of a fortnight or 3 weeks for 7 months afterwards.

Fortunately we were halted here till the 24th endeavouring, but without success, to bring the crafty Hein Se to terms. This enabled me to get on to my legs again. On the 22nd a deputation of Shans arrived on the scene from the Thibaw State, a wild motley crowd, armed with spears, matchlocks and what not.

We left Thonzé on the 24th and returned to Mandalay on the 28th by the same route. The advance was much impeded by numerous bogs, between Pyin-ul-win and Thonzé; moreover, most of the bridges crossing the streams had been distroyed and temporary structures had to be built to enable us to get along.

On the 8th January, I accompanied an expedition under Major Deshon, R.A., from Mandalay to the Shan State of Mainlon arriving at Lamaing on that day. From thence we continued to Zagabin, and Kaingyi, where we halted a day. On the 12th we marched to Taungdeik crossing the Madeya river and then ascending a very steep pass to the Shan plateau, elevation 2,600 feet. The edge of the plateau here is very distinctly defined by a long length of precipitous scarp, over which a very fine waterfall can be seen, close to the road. A good level track then brought us to Kalagwe, elevation 3,500 feet. From here the road or rather path leads down a steep pass to a valley, elevation 2,500 feet, and then crossing and recrossing a river some twenty or thirty times, we ascended by a steep climb to an elevation of 4,700 feet at Pazi, a small village on the crest of a high range which runs east and west. On the 15th we arrived at Mainlon, elevation 2,500 feet. Here we found a small body of troops had come down from the Ruby Mines, and after a small skirmish, had ejected the ruler a few days before our arrival, which was somewhat disappointing. Leaving a Sub-Surveyor with the column at Mainlon, I proceeded with the troops to the Ruby Mines, marching on the 17th January to Kyauktalon, along the valley of the Madeya river, where the road runs along the northern bank. On the 18th we marched into Mogok, the centre of the Ruby Mines district, elevation 4,100 feet, where I met Mr. Kennedy and Sub-Surveyor Faida Ali, who had accompanied the column from Kyan Nyat on the Irrawaddy. On the 25th I marched to Pyaungyaung, afterwards named Bernardmyo, elevation 6,000 feet, minimum thermometer registered 26° I returned to Mogok on the 27th January and proceeded the following day with a column under Major Skene of the Goorkhas by a new route to the Irrawaddy. On the 28th we reached Kathé, elevation 4,900 feet, beyond which the descent commences to Khabine (elevation 3,200 feet), and continues to Kinywa on the Kin Chaung, whence the road ascends to Shwenyaungbin, elevation 3,200 feet.

It then descends again to Nampan (elevation 2,800 feet) and Wapyudaung (elevation 1,700 feet). Thence the road runs level as far as Thabeit-Kyun on the banks of the Irrawaddy, which we reached on the 3rd February. Here I found a steam launch to take me to Kyaukmyaung and finally I got back to Mandalay on the 4th February.

The Ruby Mines are situated on a diamond-shaped plateau, of an elevation of from 4,000 to 5,000 feet; covering an area of about 18 square miles. There are lofty peaks to the north and east of the valley, the highest by name Taungmé rising to 7,800 feet. To the north-east, at the head of the valley, there is a long ridge running eastward for a distance of about 5 or 6 miles with an elevation of over 7,000 feet.

The mines are principally worked by a race called Maingthas, Chinese Shans, I believe, who come annually from the borders of Yunan to be employed by the local owners of the mines. At Bernardmyo there are one or two villages, peopled by a tribe called Leesaws or Kachins, I believe.

A very fine lake might be made at Bernardmyo by damming the narrow gorge which forms the outlet for the main drainage of the Engyauk valley. The hills at Bernardmyo have been considerably denuded of trees by the Leesaws and only have a growth of high coarse grass and bracken. The higher slopes, however, are clothed with evergreen forest. The soil is generally clay which necessitates the roads being paved in the swampy parts to render them practicable in the rainy season.

On the 26th February, I started with the escort accompanying the Tsawbwa of Thibaw to his capital in the Shan States after his month's residence at Mandalay. We reached Pyin-ul-win on the 2nd March and halted two days to make final preparations. From thence we marched to Bambwé (elevation 2,600 feet), Konsa (elevation 2,600 feet), Nammaw (elevation 3,300 feet), and Goteik (elevation 3,400 feet). Between Nammaw and Goteik we crossed a precipitous gorge forming the valley of the Namsan river.

The road leads from the plateau down a steep descent of 800 feet to a natural bridge of rock, about 600 feet in width, spanning the gorge, which here has perpendicular sides. On looking over the precipice, the river can be seen some 300 or 400 feet below, before it disappears under this natural bridge.

On our return journey, although the inhabitants tried to dissuade us, we endeavoured by a circuitous route to reach the orifice where the river disappears beneath the overlying sheet of rock, but after a long trudge to the bed of the river, at the junction of the Namsan and Nampan rivers, we still found ourselves some miles from our objective point, and after much wading and clambering over all kinds of obstacles, we were compelled to give up the attempt. From the bridge there is a very steep ascent of some 600 feet, the road being cut in steps on the face of the rock, and thus made practicable for pack animals and elephants.

A rude stone monument is erected on the bridge, to commemorate the work. A tablet on which there is Shan and Chinese writing, informs us that the road was made in 1862 by Chinese and Shan workmen, employed by the Tsawbwa of Thibaw and that it cost ₹20,000. From Goteik we marched to Pyaung-yaung (elevation 3,200 feet),—Kywegon (elevation 3,000 feet), Kinthi (elevation 2,000 feet), and Bawgyo (elevation 1,600 feet). Here we visited the salt wells, which are said to yield about 3½lb of salt per diem. The Tsawbwa receives half the earnings and the workers the other half. From Bawgyo, we followed the river Myit-nge, (or the Namtu as it is called in the Shan States) to Thibaw which we reached on the 14th March.

Half way between Bawgyo and Thibaw, we were met by a large retinue of officials and followers who joined the procession as we advanced. First of all came the heralds and pages, then the Tsawbwa and Mr. Bridges, the Political Officer, seated together on an elephant, followed by the queens on elephants; behind again the maids of honour on foot, who were joined by other women from the palace, decked with flowers and garlands. Then followed the troops mixed up with the populace who came out to greet us. The town of Thibaw was burnt and sacked during the Tsawbwa's absence by the Myinzain's adherents in 1886, but the palace, owing to some superstitious dread, was left untouched. The Tsawbwa, however, refuses any longer to live in it, and now resides in a bamboo palace constructed on a raft moored to the bank of the river Namtu, which flows past the town. We were all encamped on the bank close to this floating palace.

On the 19th March Captain Armitage, R.A., and I proceeded with a small party to Namyan on the south returning on the 22nd.

On the 23rd we visited Onbaung, the old capital of the Thibaw State, situated about 3 miles to the west of the present site. The position is an exceedingly strong one, surrounded by a high rampart and ditch. Some 300 years ago, a Tsawbwa of Onbaung became king of Ava, and on this account no Tsawbwa of Thibaw has been permitted since then by the Burmese Kings even to pass through Onbaung and the consequence is the place is deserted and covered with jungle. On the 29th Captain Armitage and I again started off, and reached Monglan to the east of Thibaw, elevation 2,500 feet, and from thence proceeded to Tati, on the main road to Lashio and Theinni. Here we were not allowed by the Tsawbwa's *Amat* or minister who accompanied us, to proceed across the river Namsan, as complications were feared with neighbouring States, so we retraced our steps to Monglan and proceeded in a southerly direction to Nammon, Hona (elevation 2,800 feet), Sounkye (3,000 feet) and Monkén. Here we halted to ascend Loikeu Hill (elevation 6,000 feet). On this hill we found villages inhabited by Taungshus. On 5th April we continued our route to Namlan, a large and prosperous village, and thence to

Simon, where we again met the Namtu river. Then we went to Onkok and returned to Thibaw on the 8th April. During my absence Sub-Surveyor Faida Ali was employed surveying to the north, but was not allowed to enter the neighbouring State of Taungbain, where tea is grown in great quantities by the Palungs who inhabit these hills.

On the 10th of April we commenced our return journey to Mandalay, Sub-Surveyor Faida Ali marching by an alternative route and meeting us again at Goteik on the 14th. From Nammaw, we marched across to Thonzé, and from thence to Sizon and Medaw (elevation 4,200 feet). Then to Nyaungthakaw and Pyin-ul-win, finally arriving at Mandalay on 25th April.

With the exception of the Goteik gorge we encountered no physical difficulties of any moment. Owing to recent disturbances the country appeared denuded of inhabitants who had migrated elsewhere. Deserted villages were numerous, and great difficulty was experienced in procuring supplies of any kind: the Shans are even more opposed to taking life of any kind than the Burmese, and it was almost impossible to procure fresh meat. Even at Thibaw, fowls and eggs had to be brought in from places some six marches distant.

The Shans I believe to be a peace-loving community and have only been incited to wage war one against another by the intriguing resident Burmese officials appointed from time to time by the Burmese Court. They are very fond of peddling and along every road one meets them hawking their wares. Every large village has its market day once or twice a week. They are grossly superstitious and given to exaggeration and they would infinitely sooner believe the profoundest falsehood than the truth.

Extract from the Narrative Report of LIEUTENANT H. M. JACKSON, R.E., *on the Survey Operations in the* SOUTHERN SHAN STATES,—*Season 1886-87.*

I started with one Sub-Surveyor and a Military Surveyor on the 30th of December from Myingyan on the Irrawaddy with some of the troops detailed for the "Southern Shan Column." We reached Hlaindet at the foot of the hills forming the lowest step or outer barrier of the Shan high-lands on the 10th of January. I was able to bring the triangulation up to these hills by observations from three very good stations *en route*. A road traverse was also carried on continuously, and some little detail work done about Mehtila and Hlaindet, where the military surveyor falling sick had to be left. At this latter place I took advantage of the delay caused by change of transport to ascend several of the frontier peaks in order to fix points to the front; but, owing to the thickness of the jungle and the confused formation of the hills, I was not very successful in this. However, I had to go on with the troops, and when we reached Myelat plateau, about 4,300 feet above sea-level, on the 28th, I found that, though I had not succeeded in a properly continuous triangulation, I had so many well-fixed points behind me within sight as to enable me to determine my position sufficiently well to carry on detail survey and triangulation to be afterwards connected. On the plateau above mentioned, a post was established at Pwehla and the column remained there until the 5th of February. One expedition, which I accompanied, was made about 20 miles to the north along the western skirt of the Taungmengyi, the backbone of the plateau, in which the older rocks first crop up. The Pwehla plateau or Myelat (as the district is called which holds this confederation of small States, of which Pwehla and Thamakan to the south are the chief) is a high tableland enclosed by limestone crags; its surface of red clayey soil broken up into low rounded hills, some bare, some covered with coarse grass. Most of it has been under cultivation apparently; and doubtless, when the country has quieted down, will be so again. Here and there in sheltered gullies or on hill sides less exposed to the west wind are clumps of bamboos; and on the higher parts the first pines are met with. These seem very much the same as the *chir* of the Himalayas. A little rice is grown in the bottoms; but most of the cultivation is dry and almost entirely in the hands of the Taungnus or Taungzus, a separate though nearly allied race to the Shans. They are swarthier, of more generally Mongolian physiognomy than the latter. Their women wear a peculiar dress. They are mostly industrious cultivators; whereas the Shan prefers wandering about the country with his pack bullocks, plundering his neighbours, or smoking, chewing and bragging, to any thing like steady work. The climate on the plateau was all that could be wished in January—almost too cold at night. From Pwehla we descended to the Heho valley, a bare kind of raised basin, drained mainly by one large stream into the Nyaungywe valley below. At a *zayât* by the side of the main river of the valley, we were met by the Nyaungywe Tsawbwa whose rescue from his enemies was one of the ostensible reasons for the expedition. The next day was spent in reconnoitring the said enemy's position and the same night and following day in circumventing and driving them away. After a few days' halt at the capital, Nyaungywe, about 8 miles to the south, a straggling village, built along the river, remarkable only for the brick "palace" of the Tsawbwa, we proceeded to the site chosen for the residence of the Commissioner, and the post now known as Fort Stedman, which is above the village of Maingsauk on the lower spurs of the hills forming the eastern side of the Inle Lake. The Balu Chaung—the river draining the upper parts of the valley—flows through the lake which is merely a shallow basin of some nine by two miles of clear water with sedgy edges, running into long stretches of marsh land at both ends. The villages round are many of them built out on piles over the water; their gardens

being masses of floating grass secured by long bamboos driven through into the bottom. The lake people (who rarely leave the valley) lead an almost entirely aquatic life. The children, as soon as they can stand, learn to propel a big "dug out" after the manner of their fathers, standing on one leg and working with the other, the long paddle held like a leaping pole. The lake is full of many kinds of coarse fish, and in the winter months is covered with water-fowl. Its height above sea-level is about 3,000 feet, its depth is generally very uniform, on an average 6 feet, but in a few places 11 or 12 feet is attained. The water is beautifully clear, the bottom being covered by about 2 feet, of bright green weed. From the western side, draining the Pwehla plateau the Paungdaw river enters in an eccentric manner peculiar to Shan rivers through half a mile of limestone rock instead of by its natural bed. The entrance of the tunnel is a high archway in a sheer cliff of limestone and about 150 feet below the general surface of the ground; the exit is just large enough for the passage of the water. In its passage the river or part of it is, as can be plainly heard and indeed seen in places, running just below the surface of its former bed. Many feeders fall into the lake from the eastern hills; but, these are of no great length of course. Having worked the triangulation round about this valley, as far as the constant haze would admit, and put in some detail survey, I started with a boat expedition down the Paungdaw river towards Mobye. I was enabled to time the boat past measured distances on the lake so as to plot our course *en route* by a time traverse. This I checked by observations for latitude at two places (one of which was our turning point) and by back bearings; as our course was nearly due south, I think the results are fairly correct. The farthest point made was Pevakon, a former Burmese post. Here we found the Mobye Tsawbwa a well meaning but extremely garrulous old man, who received us in a very friendly way. He seems to have abandoned his ancient capital of Mobye in favour of this place, where he can cultivate his fields in peace without being troubled by the Red Karens. These children of the forest have a very bad character in these parts from their kidnapping and generally thieving proclivities; and, from the specimens we saw at Peyakon, we were not inclined to doubt this reputation. The river, 20 to 30 yards broad, runs between parallel hills on either side, whose spurs often jut out over it; there is only one place where it is too shallow for laden boats, and only one portage has to be made between the lake and Peyakon, a distance of 80 miles; about 10 miles beyond Mobye this river disappears underground in a kind of swamp, they say. The villages along the bank are frequent and many flourishing, especially Saga and Nantók, which are capitals of semi-independent petty States. Many smaller villages had been recently burnt by raiders from the hills when we passed. We returned to Fort Stedman by the same route. I found that my Sub-Surveyor had completed a good deal of detail survey, chiefly round the edges of the lake; but the necessity of going about in a narrow "dug out" and the impossibility of setting up the plane-table steadily on the half floating shore prevented rapid progress. The main body of the column now returned to Burma; and the remainder began to prepare for a look round at their neighbours. The Yatsauk Tsawbwa, our former foe who was driven from Nayaungywe territory, was also to be moved on. I started for this trip three days in advance for triangulating purposes to north and east. Our course was to be north to Yatsauk and then east to Maingpyin, thence south into the Hopon valley just to the east of the Nyaungywe valley. We made first for Pwehla before mentioned, thence to Pindya. From Pwehla to Pindya one crosses part of the watershed of the north and south running rivers, down into the valley of the first large north running stream, the Zawgyi, which rises near Pindya. This town, one of the most flourishing in these parts, lies on the edge of a small lake under the eastern skirts of the Taungmengyi about 4,000 feet above sea-level. This whole region is metalliferous. Bauzain to the south-east of Pindya, is the chief mining place at present. There lead and silver are worked but, apparently, to no great profit. Coal is also found under the Taungmengyi to the north on the western slopes, as also just below the plateau, in the Panlang valley at Min Kalaung. Specimens were obtained and burnt of this latter; but they were weather worn blocks, and so hardly gave a fair test; they appeared, however, wanting in bituminous constituents. I was unable to carry the triangulation along to Yatsauk and Maingpyin on account of the nature of the country passed through, comprising low-lying jungle covered hills, and to the hurried mode of our march which was necessary in order to surprise the Yatsauk Tsawbwa in his stronghold; but I carried on a traverse by compass, which was checked by observations for latitude at Yatsauk and an azimuth connected with a high peak of the Taungmengyi previously fixed from the west.

The rest of this work was similarly done until I got in the Hopon valley on to points intersected from the east wall of the Nyaungywe valley. I found my traverse fairly correct. We just missed the Yatsauk Tsawbwa, so after a short halt in his town (height above sea-level about 3,280) a straggling village on the Zawgyi river protected by a once strong fort built with brick wall and deep ditch on a small hill partly encircled by a natural moat, we proceeded across the river and a low range of hills to Maingpyin. Maingpyin seems to have suffered a good deal in recent disturbances and is now almost deserted, as are all the villages to the south of it, until the higher Hopon valley is reached by a gradual ascent through a very good pass between broken hills. I mapped the upper portion of the valley of the Tabet river around our camp at Hopon, and fixed some points for extension of triangulation on the Loisang range bounding the east of this valley. The Hopon valley here is fairly open and well irrigated naturally and artificially. It has evidently once borne a considerable cultivation; but recent raids by neighbouring chiefs and the

requisitions of the "Limbin" Prince have stopped this and driven the people from their villages. The river Tabet Chaung is fed by several streams running underground from the higher hills to the east through tunnels in the limestone and emerging close to the centre of the valley near Hopon village under small craggy promontories. From the west and north the tributaries are fewer and small, being ordinary streams. The hills separating the Balu Chaung and Tabet valleys rise in the outlying peak of Myinmati to 6,600 feet. Those between the Tabet and Pon valleys to the east reach 7,500 feet. From Hopon we crossed the Loisang nearly east to Mainpon, a large village on the Pon river. The Tsawbwa was found engaged in hostilities with his neighbours of Legya. He was, in fact, in a state of siege; but, as the combatants had been for some weeks entrenched behind basket-work stockades continually firing away at each other, and the only acknowledged casualty was one messenger who was not personally interested in the proceedings, it may be imagined the affair was not serious. In fact, a little persuasion from the Assistant Commissioner and a square meal from the besieged induced the besiegers to depart without further ado. Mainpon is a flourishing little state; the fields below the town are cleverly irrigated by large bamboo water-wheels worked by the river. The Tsawbwa appears a very intelligent and energetic man and something of a sportsman: unlike most royalty in these parts he heads his army in the field. The Pon river rising some distance to the north in Legya, runs at first due north according to reliable accounts, then turning in a sharp curve makes south, enters the Mainpon valley from the north-west, and thence runs due south to form like the Thein and Ben rivers to the east, one of the principal tributaries of the Salween. From the Loihan hills bounding the east of this valley I did my best to throw cut points for triangulation to the east and south, and I mapped the country round about the town and neighbourhood. The main body of the expedition then started back to Fort Stedman. The remainder, *viz.*, an officer and 50 men of the 27th P. I. accompanied by a medical officer, the Assistant Commissioner and myself, proceeded across the Loihan towards Mone to secure the person of the Limbin Prince.

The descent from the pass to the village of Banpien was very steep, over smooth clay; in wet weather it is impracticable even for Shan pack bullocks. From Banpien on the Kong river we made due east across flat open country at first, and then through low rocky hills to Hepet. Fever prevented me from doing more than a very rough traverse *en route*, but I found myself there close to points fixed from the Loihan. From Hepet the road to Mone leads south straight down along the banks of the Namtwan river, through a narrow valley bounded by jungle-covered hills. Except in one place about half-way, where there are some rice-fields, there is no cultivation nor any village after leaving the neighbourhood of Hepet. Arrived in Mone we encamped under a large fig tree in the town. Little notice was taken of our arrival, though we came with the brother-in-law of the Tsawbwa who had been our *chaperone* for some time. There was no ill-feeling, however, and the ruling prince subsequently made himself as agreeable as his circumstances admitted. The people looked sickly and hungry. Here finding my work rather adrift, I measured a temporary base and made careful observations for azimuth and latitude and proceeded with a temporary independent triangulation. This rather prevented any detail work. Mone was apparently once a large and flourishing town but has now fallen into decay partly from continual disturbances, partly from the unhealthiness of its situation increased by the lapse of former rice-lands into wet waste. It is built on the side of a large marsh formed by the Namtwan and its affluents. On three sides of the town the spurs of the hills shut it in closely. The remains of the encircling walls however and several large pagodas bear witness to a more prosperous past. Evidence being accentuated by the present dirty squalid state of the bamboo houses, and the very unpalatial nature of the "palace." Here one is amidst a tropical vegetation again, cocoa palms have taken the place of pines and the voice of the *taktu* is heard in the land. The Tsawbwa of Mone is certainly the best-bred man we have met in the Shan country; he is of weak health however, and so relegates most of the practical business of his realm to the brother-in-law abovementioned. With two others of our party I travelled to Maukme which lies to the south about 24 miles—long miles to cover in one march as we did. The road leads up and through the hills on a fairly good line until the Maukme valley is sighted. Here one descends rapidly by a zig-zag into the rice-flats below.

We were received a mile outside the town by the "Pillars of the State" accompanied by a motley crew of variously armed warriors and thence escorted with all the barbaric honours of drum, gong, cymbal and other instruments of music to the quartres prepared for us in a *zayát* at the further end of the town. We passed through the one long street of the town (nearly a mile long), the cause of much apparent wonder, and when we reached our lodgings our admirers were constant and untiring; however, they only looked. I could only hope for single rays or very acute intersections on any points near Maukme so I proceeded at once to observe for latitude. The next day I got in the general topography of the valley, and fixed peaks from a base measured on a long plain which I hoped to connect subsequently with Mone. The Tsawbwa paid us a visit in state during the course of the day. He was gorgeous in the extreme; he is a mere lad, but sufficiently at home on his throne. His ministers are very old men, wrinkled and grizzled by the cares of State. There was a somewhat Burmese air of luxury and show about this court. The Tsawbwa's gilded chariot too with six men in the shafts and others holding golden umbrellas over and round about him, showed a condition of luxury unlike anything we had previously seen. In the afternoon, whilst I was working about the valley, the others returned the Tsawbwa's

visit. They were received and entertained in the presence of the old king who lay embalmed in state, surrounded by his widows attentively fanning the flies away from his late royalty. Under the bier a musical box discoursed popular airs, and helped to make things cheerful. My observations this night were interrupted by heavy rain. The next day at daylight we started back to Mone by the same road. Maukme is decidedly the most flourishing State we have seen, and the town the largest and most populous, and apparently the richest in this part of the country. The whole broad, flat valley is irrigated by many large channels and every available piece of ground is cultivated. The vegetation of the valley is more distinctly tropical than that of Mone. The river on which the town is built is called the Namyon ; it comes in from the north-west and must carry down a considerable quantity of water.

Having returned to Mone and the arrangements for the transport of the Limbin Prince being complete, we started back westward after a final entertainment of tea and cheroots at the palace on which occasion the State geographer displayed a most excellent map of the Shan States in the style of that country. We left Mone by a road leading out over a low pass in the hills to the north-west. As soon as the Namtwan valley is left, a sandy, hilly country is reached, where the pine is again the most frequent tree. Crossing this tract the road leads due west into Mainzaik territory and a fairly cultivated valley. This is the valley that we crossed to the north at Banpien. On our way I tried to connect my Mone triangulation with some of my more western points ; but, rainy weather having set in, I was not completely successful. The result was sufficient, however, to connect the mapping. Mainzaik appears a well (rice-) fed place ; but I had not time to see much of it. Hence we ascended by a very steep road in very bad weather to a camping ground at the top of the Loihan. Unfortunately, at this camp I was just on the wrong side of a deep valley to get at one of my observed points.

The next day we descended into the Pon valley and camped near a small village some 3 miles down across the Pon river, which is about 50 yards broad and up to a horse's belly at the ford. From this the road continues about 4 miles down the valley, which is here very narrow and tortuous, the hills having a steep descent close to the river. The ascent of the Loisang, which is there steep and long, was made to a neck on the south of the highest peak of the range. We camped at a village some way down the other side, and next day reached and passed through Banyin at the foot of the hills, camping on the Tabet Chaung which is here broad and too deep to ford. The morrow we crossed the river on rafts and I was able to complete some plane-table work *en route*, though I had not time to fix or name all the villages that line the banks of the river in this part. After one night's halt on the skirt of the hill, we crossed by the pass below Myinmati Peak (which I again ascended *en route*), and eventually reached Fort Stedman. I had been ill for some time past and I had to lie up on return to this place. When I had sufficiently recovered I began my return journey to the plains.

At Pwehla I picked up the Sub-Surveyor who I found had done some very careful detail work round this place, where I had left him on our march to Yatsauk. From this I proceeded slowly patching up my imperfect triangulation to Hlaindet, whence I again ascended the highest of the frontier peaks near Eupa, cleared several long rays through the trees and succeeded in fairly well establishing my through connection. From Hlaindet the Sub-Surveyor and I proceeded with a road traverse along the foot of the hills from which these hills were sketched in as far as Thabyedaung. I was able also on the way to connect my southern triangulation directly with that of Captain Hobday's brought from Mandalay. We reached Mandalay on June the 22nd.

Report on the Survey of OLD PAGAN, UPPER BURMA, *by* LIEUTENANT H. M. JACKSON, R.E.

The city of Pagan seems to have been of considerable extent, as evidenced by the remains of the wall and ditch encircling it. Nothing, of course, now remains of the ordinary buildings of this city ; they were presumably, like those of other cities of former and present times in these parts, built of perishable material. There is no doubt, I believe, that the city formerly extended further to the westward, where the river now runs, and part of it was probably on an island called, according to my guide, Nagamanda. It is easy to see that round the promontory on which the village of Nyaungu now stands, the river may have, and probably has, run a very different course not many years ago. The pagoda called Singyigôn, the furthest big pagoda to the north, appears to be still the most ornate. The gilding is well kept up ; and, when I saw it on a festival day, crowds of people were praying round, and gorgeous tapestries decorated it from spire to basement. It is said to be, according to my informant, the oldest of all the pagodas, and to have been built by a king called Natha (?) 500 years ago. The Ananda pagoda, which is also still well kept up, is of entirely different design to the others. Its plan is in the form of a cross, on each arm of which is a kind of chapel, where, rising from floor to roof, his legs only visible from the entrance, a gigantic *Gotama* (saint) in gilded *bas-relief* presides. These figures are very conventional. The *tout ensemble* of this pagoda, especially when it is viewed from some little distance, is far better than that of any other. The pagoda itself is in good repair, though the enclosure walls are beginning to decay. It was, I am told, built by a king named Chaya (?) 300 years ago.

I could only spare one day at Old Pagan; so in the afternoon I walked out to the furthest large pagoda to the south, the Pailonjaw. This is of circular plan; it is of red brick and merely a massive ruin now encircled, as to the tiers of the dome, with green moss. The design is good, and it must have been a grand temple in its day. Standing on slightly rising ground and backed by the hills, it seemed, as the last rays of the setting sun rested on it, a worthy witness of the greater past.

These three pagodas that I have mentioned are, I think, the principal large pagodas existing; as to the others they are of various sizes and shapes, but two designs seem chiefly to predominate. I gathered that the smaller pagodas, none of which are kept in repair, are all of later date than the big ones I have described. This seems probable in a climate in which the permanence of a brick-building simply depends upon the state of the coating of cement or plaster outside it, though they bear an appearance of greater antiquity.

From the remains of (probably) the side of a gateway of the ancient walls, a fairly high mound from which most of the country round can be seen, I tried to find some idea of former arrangement in the confused mass of ruins on all sides, but unsuccessfully; and from the map it is evident that none existed, at least at the time the place was deserted. This latter event, according to my guide, occurred 180 years ago; but this is evidently absurd: however, I give his statement as a datum from which (for I presume the real date is approximately known) his other dates may be proportionally corrected. The town had existed for 400 years according to this man; and as to the reason for the fact of such a collection of pagodas, he told me a story to the effect that a king named "Noatamin" brought a very holy *pongyi* (priest) from China, and that in fulfilment of some oath or agreement, wherever the elephant which was ridden by the *pongyi* stopped and knelt down, there was to be built a pagoda. Apparently the elephant had a way of doing this; and, as he could not be expected to possess an eye for architectural arrangement, this legend also accounts quite satisfactorily for the lack of this quality in the building resulting.

I tried to interview the prince who still resides in Pagan in order to obtain some more reliable information. He belonged to the last semi-independent dynasty of Pagan, the members of which were turned into "pagoda slaves" by the conquerors. He is no doubt the man who knows most about Old Pagan; but, though through the Deputy Commissioner he had promised to come, he failed to put in an appearance, and I had not time to go to him. The names of the pagodas, &c., were all written down on the spot by this guide who was kindly deputed by Captain Eyre, Deputy Commissioner, for the purpose; they at least are correct.

Extract from the Narrative Report of COLONEL R. G. WOODTHORPE, R.E., *on the Survey Operations in the* KUBO VALLEY, &C.,—*Season 1886-87.*

I will now proceed to a brief narrative of our proceedings during the season. We reached Manipur on the 8th December and remained till the 13th, when, having made all arrangements for guides, small Manipuri guards and supplies, we separated, Mr. Ogle going to Sanaching H. S. and I to Munoi H. S. On the way Mr. Ogle started Bapu Jadu at his work. Mr. Ogle soon had Sanaching, Manchinbung and Kamong stations ready, and having observed to them from Munoi I went on to Tammu *vid* Yangopopi *thana*. I reached Tammu on the 21st December and halted next day to pay up and discharge Manipuri guard and guides and fix the position of Tammu. On the 23rd I took the coolies up to a hill, Laiching, about 3 miles north of Tammu which afforded a good station and began to clear it. I was joined here by Mr. Ogle, and on the 25th we returned to Tammu to eat our Christmas dinner with the officers there—Major Dyce, D. A. A. G., North-East Frontier, Lieutenant Berkeley, 44th Regiment, G. L. I., Dr. Younan and Mr. Mitchel, a young C. E. in charge of the new cart-road between Manipur and Tammu. General Gordon, Commanding the North-East Frontier, had gone on to Kendat. On the 28th we again separated, Mr. Ogle returning to Munoi and Laiching to observe, while I went on to Auktaung, where I found Captain Stevens, who arranged for me to go to a high point above Kampa, which I intended to make our next forward station. As I wished to see General Gordon, who was to return on the 2nd January, I employed myself in the meantime in putting up crow's nests in a couple of lofty trees, one at Auktaung the other on a low range 3 miles to the east, from these I was able to fix my positions and do some topography. The General returned on the 3rd and I had a long talk with him about our work. Nothing had been settled then about the Kubo question, and he and Captain Raikes, Deputy Commissioner, Chindwin, were anxious that our operations should not include clearing some peaks on the Angoching range, where we had hoped to make stations, from which to extend our triangulation eastward. They thought that the suspicions of the Thaungdut Sawbwa would be aroused and that he would mistake our marks for boundary pillars. We eventually got a couple of points lower down on the range out of Thaungdut territory, but our work would have been a little better had we been able to clear the peaks we had first decided on. As there was no objection to my going to the peak above Kampa, I started on the 4th reaching the village in the afternoon. It had lately been visited by Chins who had utterly destroyed it; nothing but a few charred sticks remained of what had been rather a fine village. Dead half burnt buffaloes lay in unexpected corners, or in the jungle, poisoning the atmosphere, and I was glad to get away next morning. We did not reach the peak that day, but on the 6th I succeeded in finding it. There was not much

clearing to be done, and it turned out an excellent and most useful point. It overlooks the whole of the Kubo valley on one side and on the other Kendat and a long stretch of the Chindwin. On the 12th I returned to Tammu having done all I could in the southern portion of the valley. At Tammu I again picked up Mr. Ogle, who had been doing some good work, and together we went to one of the points on the Angoching range already alluded to, returning to Tammu on 17th; on the 18th I took the opportunity of the return of some influential refugees from Kendat to their houses to send Bapu Jadu with them in boats down the Yu river to Kendat. He surveyed the whole of the stream with the subtense instrument and made a valuable addition to our maps. On the 21st Mr. Ogle left for Auktaung to survey the country between that place and Kendat by a road called the Minthami route and to do some more triangulation.

The 22nd was too wet a day to move, but on the 23rd I started with the General by the Sweja route for Auktaung on the Chindwin, which we reached on the 25th. Here we met Lieutenant H. Daly, Political Officer in charge of the Lekayain district, a very able and zealous young officer, whose head-quarters were at Poungbyin, and with him I started for Poungbyin. On the 26th we stopped for the night at a place called Kaia, and here cholera broke out among my coolies. Mr. Mitchel had had cholera among his Naga coolies while at work on the Sweja route; we stopped at one of his camps for the night, and must have picked up the disease there. The first case occurred at 8 P.M. just as we were going to dinner. Mr. Daly sent to the priests, who kindly placed one of their small houses at our disposal so as to remove the sick man from his fellows; the native doctor and I remained with him till 12, and just as I was going to sleep, a man lying immediately under that portion of the raised floor where my bed was, began to groan. Getting up, I found he also had been seized and I removed him to the *sŕát* where the other poor fellow was lying. The doctor and I again did what we could till 2 A.M., without success. At 6 A.M. a third man was seized. The first two died in the early morning, the third lingered till the afternoon; a sepoy was also seized in the morning and we sent him up by boat with the sick coolies and the doctor to Pouñgbyin. All the arrangements for the dead and sick delayed us, and as we had a long march of 23 miles, a good deal of it through slush and mud, we did not get in till very late. The next day we halted to let the native doctor join us and to rest the coolies. Poungbyin is a largish village on the Chindwin, 70 miles above Kendat, and on the opposite bank is a large marsh and lake where wild fowl of all kinds literally swarm. Subadar Hema Chand, of the 44th G. L. I., stationed at Poungbyin, used frequently to go out for a comple of hours of an afternoon and return with a couple of geese, six or seven ducks of various kinds, not to mention snipe and such small game. He is a great shot either with gun or rifle; and somewhat rare for a native—brings down birds on the wing as easily as when sitting. On the 29th Mr. Daly and I with a guard of 50 men of the 44th under Hema Chand, started on a trip to the Uyu river; we marched up to Homalin by land, returning by river in boats, paying a short visit to the Tsawbwa of Thaungdut on our way down. He was very friendly and said we might explore any part of his dominions. On our return to Poungbyin on the 7th, we found that the place had been attacked two days previously and part of the village burned before the garrison under Captain Boileau succeeded in driving them off. The Berthon boat which I had with me on my trip to the Irrawaddy in 1885 was sent down to me with my Khasia coolies from Shillong where I had left it when I went to Gilgit, and it proved most useful on the Chindwin. It is easily carried by one coolie. I sculled myself nearly the whole of the 70 miles between Homalin and Poungbyin, and I was able to explore small creeks on the way, and going ahead could look about for good plane-table stations before the heavier boat, in which were my *khalásis* and plane-table, came up and thus time was saved. I had intended after this trip to have gone down to Kendat, but rumours of dacoits being in the neighbourhood induced Mr. Daly to organise two more little excursions eastward in the hope of catching some of them; and although we were disappointed in this, I was enabled to do a good deal of work. I finally reached Kendat on the 27th February where I found Mr. Ogle who had made all arrangements for commencing the triangulation of the Chindwin.

On the 1st March Mr. Ogle went down with Bapu Jadu to a point we had fixed a few miles down the river and pointed out the hills ahead which the *bábu* was to clear, and on the 2nd, having got all his men and boats together and a guard of the 6th B. L. I., he started off down stream, while Mr. Ogle went back to a station on the Minthami route to observe some necessary angles. Till the 6th I was employed at office work with the writer, and in advising about the curtailment of the stockade which was far too large for the garrison intended to be left there. On the 6th I left with Colonel Toker and Captain Raikes in a steam launch for Mingin, in which district a rebellion had just occurred, and there seemed a chance of being able to move about with the troops. However, this rebellion had collapsed and the leader, Budayaza, had been captured before we reached Mingin, and so I returned with Captain Raikes to Kaléwa. Thence he despatched messengers with presents to the Tsawbwa of Kale, whom he had been trying for some time to induce to make his submission. The message was to the effect that he and I, being now in the neighbourhood, would pay him a visit, if agreeable to him. Kaléwa is situated at the junction of the Myittha (the Manipur river) with the Chindwin, and is the port of the Kalé country. In consequence of the disturbances in the Mingin district, the Kendat authorities recalled Bapu Jadu, and finding that both he and Mr. Ogle were detained idling at Kendat, I asked Captain Raikes to employ the few days we had to wait for the answer from Kalé in taking me up to Kendat and starting the triangulation again. This, with his usual

readiness to oblige, he agreed to, and once more work was resumed. It was now getting very hot and all the hill sides were wreathed in flames from jungle fires, the smoke from which rendered the atmosphere very dense, and greatly hindered our work henceforth. Through no fault of ours whatever we were just a month too late for the triangulation.

The country to the east of the Chindwin above and about Kendat consists of a confused mass of low hills, or table-lands, intersected by numerous ravines and water courses and enclosing small flat cultivated valleys. The only possible way of surveying this country is to traverse the small streams and village paths. These hills and plateaux seldom obtain a height of 500 feet above the general level of the plain, and are all of such an uniform elevation that it is of no use to make clearings for plane-table work. Below Kaléwa also, the country through which the Chindwin flows is so low, or broken up into such a confusion of low hills, that little or no topography could be done from any of our trigonometrical stations, and, as I before stated, military considerations prevented our leaving the river banks for any distance.

Kaléwa is very prettily situated on an elevated tongue of land between the Myittha and the Chindwin. The one street of the village runs along the ridge, gradually rising to a commanding eminence crowned with numerous graceful pagodas, idol houses and *ziáts*. Here the sepoys lived and I also had a *ziát* to dwell in—a nice airy building overhanging the river far below. The whole of the platform is of brick and formed a perfectly firm foundation for the theodolite in taking observations for latitude, and here I obtained the best results. Each pagoda spire is crowned with the usual *hti*, or gilt umbrella, with nine small bells attached to each; at night when a gentle breeze plays over the hill, the air is full of sweet sound, which rises and falls with beautiful effect. Often I lay awake at night listening with pleasure to these innumerable fairy tinklings high overhead, which mingled with my dreams when at last I slept. Around Kaléwa rise high peaks sloping to the south and east, but falling in abrupt precipices to the north. At night we could see the jungle fires creeping like snakes in long undulating lines up these steep slopes. I asked Captain Raikes' Burmese servant, how these fires originated. He said "at this time of the year the ground is covered with dead leaves and dry grass, rocks roll from above on to others below and strike sparks which set light to the inflammable dry vegetation." We were inclined to pooh-pooh this explanation at first, but further questioning of other entirely independent witnesses, always elicited the same reply.

When we went up to Kendat I had left instructions with my *chaprássi*, Jhanu, to go up to a conspicuous point about 3 miles from Kendat and 2,400 feet above it, and put up a mark; on my return I found he had not done so. He had started with the intention of getting up, but the day was hot and the climb a stiff one, and the guide took them by an unnecessarily roundabout route, probably from not clearly understanding where he was wanted to go. We could get no regular interpreters on the Chindwin; those we had brought from Manipur insisted on returning from Kendat, and after that we had to trust to any sepoy or frontier policeman who might have picked up a little Burmese. Captain Raikes kindly helped us with a man occasionally, but he himself was very short-handed and could not often spare him. To return—the sepoys were disgusted at having to climb hills, being principally long Pandis of the 16th and they dawdled and sat down frequently, saying they were not built to climb hills, and when Jhanu remonstrated and said if I had been there they would have been up in half the time, they replied irreverently "Bosh! Is he a bird to fly up this confounded hill?" And so Jhanu came back with his work undone. I therefore, on the night of our return to Kaléwa, requested the *subadár* commanding our 16th escort, a very nice gentlemanly man, to pick me out a few good walkers and we started next day at daybreak; crossing the Myittha took us some time and we left the opposite bank at 7 A.M. It was intensely hot, the slopes were very steep and covered with dry leaves and grass, slippery to a degree. The range is quite precipitous to the north and slopes at an average of 40° to the south, the ridge being a mere knife edge barely wide enough for foot hold; indeed where we put up the mark, we could not keep a footing till a little earth platform had been built up. We reached the top at 9-45 and flashed down to Kaléwa, to the intense astonishment of the sepoys who had gone with Jhanu. An idea of the steepness of the hillside may be formed when I say that when I had my lunch, a hole had to be dug for me to sit in and smaller ones for my heels, my feet being further supported by a log pegged up below them. I got the mark up and returned to Kaléwa in the evening.

The next day an answer came back from the Tsawbwa to the effect that raids by Chins, which were frequent just then, kept him at Indin, his temporary capital, and so he could not come to Kaléwa, but he should be delighted to see Captain Raikes at Indin if he would take the trouble to go so far; so we made all arrangements to start on the 15th March. I had my Berthon boat with me and it was the delight and admiration of all the Burmese. At Kendat and Kaléwa I frequently went out for a scull in the evening, and there were always several little naked urchins on the bank waiting for me, and when the boat was launched, they stepped in after me with as much calmness as if it was the regular ferry boat. Their confidence in me and my boat was highly gratifying. On the 15th we started, the whole party in boats, for Indin. On the way up we passed one or two villages which had been lately looted and burnt by the Chins, in dread of whom the villagers built huts on piles in mid-stream, or roof over boats lashed together in pairs and moored far out in the river; and to these temporary abodes they retire at night, as Chins have a dread of water and will not venture in any deeper than their knees. About 3

miles above Kaléwa is a large out-crop of coal, of which a good deal had been taken out for the steamers plying on the Chindwin. The bank had been undermined and further excavations were dangerous and had been stopped for the time when we passed up. I made a careful survey of the river as we went along. We reached Indin on the afternoon of the 17th and landed at a point about 3 miles off, whence a path to Indin cut off a great bend of the river; and here the Tsawbwa met us in great state with a procession of girls carrying vases of flowers on their heads, musicians, dancing-girls, matchlock-men, and spearmen and personal attendants bearing a gold umbrella over him. He mounted us on two elephants with funny little *howdahs* like a baby's dressing tray, with only space in each for one person, and conducted us in state to Indin, where we were installed in a very fine and commodious priest's house (*Poongyi Kyoung*). The next few days were spent by Captain Raikes in bringing his negotiations with the Tsawbwa to a satisfactory conclusion. At first nervous and suspicious, the latter soon acquired confidence in our good faith and became quite friendly. I visited a curious limestone hill about 7 miles off one day and got a good view of the valley; and from this and other points around Indin, I managed to secure a good deal of topography, though jungle fires and thick haze prevented my doing as much as I should have liked and could otherwise have done. While at Indin, my time was spent after dinner in taking stars for latitude, and Captain Raikes kindly assisted me greatly both then and on other occasions by recording for me. We were fortunate in meeting some influential Chin chiefs while we were there, and they had a long interview with Captain Raikes in which they agreed to use their influence in putting down raiding on the Tsawbwa's territory. We left Indin on the 22nd, well pleased with our visit, and reached Kaléwa on the 23rd. On the 27th we steamed down to Mingin, and on the way we saw Mr. Ogle's camp and anchored. He came on board for an hour and reported progress. I was very sorry to find he had been suffering from a bad attack of fever for a few days, but was recovering and had got on well with the work. On the 28th Captain Raikes very kindly sent the steam launch up to Mr. Ogle; and this enabled him to finish his work, as far as Mingin, by the 30th when he joined us.

On the 1st April we took Bapu Jadu up to a point suitable for a station and left him to clear it and pointed out some hills ahead which we wished him to clear, and then started in the steam launch, which thenceforward was at our disposal, to go up the river again to observe from all the stations which Mr. Ogle and the Sub-Surveyor had been putting up. We managed it in this way. There was no room in the launch for us to sleep comfortably, so we took the outer fly of Mr. Ogle's tent which was large enough to afford us both shelter, and was very quickly pitched and struck. At dawn we rose, got our few traps on board and started for the nearest station, having *chhota hazri* on board. I deposited Mr. Ogle and his party on the bank at the landing-place for his station and went on to mine, sending the launch back when I had landed. As soon as Mr. Ogle finished his work, he signalled to me, and I could then guess the time he would take to rejoin me; we then went on together. Sometimes though rarely we could visit two stations each during the day, but generally three altogether were all we could manage. We got back to Mingin on the 6th and waited a few days hoping to see the Sub-Surveyor's onward marks; we saw one but could not make out any clearings on the high range. I then received a letter from him saying he was in difficulties trying to find the point. He had been out in the jungle all one night with only 1½ *seer* of raw rice among his party (40 men) and no water. He wrote, "all night we are making mats, &c., for the mark, for we think that surely in the morning time we shall see the high hill." But when starting to "search the high hill" he found his men too tired to do much, and as they clamoured for water, the guide led them right down to the Chindwin on the opposite side of the range from their camp, and though they got water and a little more raw rice, they had a weary trudge back to camp, which they did not reach till 9 P.M. Mr. Ogle therefore started on the 10th to put things right. He returned on the 14th, and on the 15th and 16th we observed at stations near Mingin. On the 14th we received the first *dáks* we had had since 5th March, owing to confusion resulting from our postal line being changed from "*viâ* Manipur "to" *viâ* Mandalay."

On the 17th news came that a new steamer going down the river between Mingin and Alon had run aground, and it was doubtful whether our launch might not be wanted to assist the steamer. Our departure was therefore delayed a little, but we were able to start on the 18th, and observing at several stations on the way, reached Alon on the 21st, where we halted for one day to bring up arrears of correspondence, and then returned up the river observing. All our work above Alon was finished by the end of April, only a few points remained south and east which the Sub-Surveyor cleared. At Alon we lived on board a steamer, as accommodation was limited in the small bamboo matted hut which did duty for quarters and mess-house for the officers of the garrison. It had been very hot for some time past, the thermometer going up to 104°—106° frequently during the day. The anchorage was not as salubrious as it might have been, and the result was that I got a touch of fever in the first week in May. I was very anxious to visit Lepadaung H. S. to pick up some points I had previously observed to, and I went down one morning when I ought to have stayed in bed; we had a long walk across a barren, stony plain, and up a ravine where the breathless atmosphere was like a furnace, finishing up by a very steep climb of 700 feet. With Mr. Ogle's assistance, I finished the observations and got back to the steam launch, but I had to go to bed on my return to Alon and was on my back till the 24th, *i.e.*, nearly three weeks. I was moved up on the 15th to the officers' barrack.

Captain Sage very kindly giving up his little room to me, and all the officers, from Colonel Toker downwards, did what they could for me. The resources of the place were limited, there was no ice, no sodawater, no champagne, the commissariat bread was almost uneatable, and I lived on tea and indifferent soup for the three weeks. During this time Mr. Ogle was very busy visiting Chaukkah twice, having been disappointed by the weather of seeing all he wanted on his first visit. Some heavy storms having cleared the atmosphere he was more successful on the second trip. At last on the 24th May, a steamer came and took us all to Mingyan, where Captain Hobday met me. Mr. Ogle and I left for Mandalay on the 26th in the mail steamer and there, thanks to the kind care of General Sir G. White and Captain Hobday, I rapidly recovered strength, and after a fortnight's stay we proceeded down to Rangoon, picking up our party on the way down. We left Rangoon on the 22nd June and reached Calcutta on the 25th and Shillong on the 17th July.

On the whole the party was fairly healthy. We all suffered at times from fever and diarrhœa, but the attacks, till my last, were not very serious. As related I lost five men from cholera on the way to Poungbyin, and a few succumbed to pneumonia and dysentery.

Without our Khasia coolies we could not have finished our triangulation. They were always at hand, knew exactly what was wanted and carried better loads than the Burmans.

My thanks are due to all officers, military and civil, with whom our work brought us into contact, for their courteous and ready assistance to each member of the party. In the early part of the season I was indebted to General Gordon, Captain Stevens, and Mr. Primrose; and afterwards, when we crossed to the Chindwin, to Colonel Toker, Captain Raikes and Lieutenant Daly. I am more especially indebted to Captain Raikes, however, as his kindness in placing a steam launch at my disposal, and his valuable assistance in many other ways, enabled us to bring our work to a more speedy and satisfactory close than we could possibly have done otherwise.

TRANS-HIMALAYAN EXPLORATIONS.

Notes by COLONEL H. C. B. TANNER, *on Explorations in Bhutan and on the Lower Sangpo river.*

The little that has been added to our knowledge of Bhutan since the days of Captain R. Boileau Pemberton's mission to the court of the Deb Raja in 1837-38, may be summed up in a few words. On the west, Major Godwin-Austin, who accompanied Mr. Eden's mission in 1864, made a route survey from Daling in South-Eastern Sikhim to Punákha in Western Bhutan. In the east the "Pundit" traversed the outlying tracts of Men Táwang and Men Chhuna; to the south the party under Captain Harman fixed by trigonometrical observations such peaks as were visible from the plains of Assam and Bengal, and besides this, a small strip of country immediately adjoining Sikhim was sketched by Mr. W. Robert, of the Survey of India. Bogle's and Turner's missions to Tibet in 1774 and 1783 passed through Western Bhutan, but the geography furnished by Turner is meagre and Bogle gave none. We now, after a long interval of time, have the first additions to the geography of Bhutan in the shape of route maps and descriptive itineraries by explorer R. N. and a small route by P. A. who accompanied him, a short summary of which work was given in paragraph 267 of last year's Report. The diary of R. N. when published will be read with interest by geographers. It is so clear that a detailed abstract, such as is usually given with exploration reports, is not necessary, and a summary only will be given together with such marginal notes as may be requisite on the body of the reports.

The prime object of R. N.'s journey was the settlement of the Sangpo question; but though owing to political and tribal complications in Tibet and Bhutan he failed in this, he has yet brought back a very interesting piece of work. At Biákajong he joined Captain Pemberton's route with a disagreement of only 5 miles and at Se Shankar in Tibet he joined Lama U. G.'s route, where the discrepancy between the new value of its position as compared with the Lama's is only 7 miles.

In Western Bhutan R. N.'s work is of no great importance. It, however, ties together the traverses of Turner, Pemberton and Godwin-Austin, and besides, gives information in the gaps between their routes. P. A. has furnished details in the Há-Chhu (Har-Chhu of Godwin-Austin), but beyond this he has not done much.

Although R. N.'s party did not reach the Lower Sangpo, yet the narrative of K. P. gives a certain amount of information regarding that river; and as that person reached Onlet one stage from Miri Padam, the abode of the Miris and Padams, near the place where the Sangpo emerges from the Himalayas into Assam, I conceive that no further doubt should remain even in the minds of the most sceptical as to the identity of the great river of Tibet with the Dihang or Dihong, known lower down as the Brahmaputra.

R. N.'s party started from Darjeeling on the 1st November 1885 and he commenced his traverse at the Pango-La pass. From this point he travelled over new ground in Bhutan territory, to the Túle-La pass, where he joined and followed the route taken by Mr. Eden's mission as far as a point about 4 miles south of Tumphiongjong, where he crossed the Ha Chhu into the Giábba district. Continuing down the Ha valley he met Turner's route at Darbirjong (Darbi of the published maps) and followed it to Baxa Duár.

SKETCH MAP
TO ILLUSTRATE
COLONEL TANNER'S MEMORANDUM
ON EXPLORATIONS IN
BHUTAN AND TIBET
BY R.N. AND P.A.
DURING 1885-88

NOTE.—The routes of Explorers R. N. and P. A. are coloured red.
Additional routes previously explored are coloured burnt sienna.
Peaks fixed trigonometrically are shown thus 0
their heights being shown thus ..... [illegible]
Heights fixed by Captain Pemberton's Mission are shown thus ..... [illegible]
Heights fixed by R. N. are shown thus ..... [illegible]

R. N.'s companion P. A. entered Tibet by the Jelap-La pass and proceeded down the Ammo Chhu river to Assamthâng fixed by Mr. Robert in 1883. Here he struck up the small valley of Langmar Pochhu, which he left near its source by the Chhu-La pass. Crossing a valley and passing a lake or *tarn* he ascended and crossed the Miru-La (written Merugla in the Tibetan character) and proceeding down the Ha valley joined R. N.'s route near Battejong. The Miru-La was approximately fixed by Mr. Robert in 1883, and P. A.'s route has been made to originate from this point, the topography to the west being taken from Mr. Robert's sketch map. R. N. describes the inhabitants of the Ha valley and adjacent tracts as being kindly disposed towards strangers. They are termed Ha Pa by the Tibetans and talk a *patois* of Tibetan. The Ha Pa inhabit the Lachen and Lachung valleys in Sikhim, Chhumbi in Tibet, and the Giâba district in Bhutan. Bhutanese or Duk Pa race occupy the central part of Bhutan and talk Duk Ye, a language distinct from Tibetan but written in the same character. The meaning of Duk Pa is "son of Thunder" (Boanerges), and the people are so called from their powerful physique and passionate and overbearing natures. R. N. met the Bhutanese or Duk Pa only below Giâba on the Wong Chhu (Tchinchoo of Pemberton) and in Pumthâng.

The Wong Chhu or Tchinchoo is one of the seven great rivers of Bhutan and was described by Pemberton who crossed it near Tashichhujong, as follows—

"It flows through its entire extent from the capital to the Buxa Dooar through a limestone country by a great gap which for about 20 miles south of Woolakha (Olaka) appears to have been the consequence of a violent upheaving of the strata by which they have been made to dip away on either side from the river, the line of lowest level forming the present bed of the stream. The general character of this river more nearly resembles that of the Monas than the Machoo; like the former it rushes with great impetuosity over a bed almost entirely filled with large boulders of limestone and fragments of mica and talcose slate, which are the principal formations observable in the valley of the Tchinchoo."

And again—

"in one or two places the river may be forded but the attempt is attended with considerable danger from the slippery surface of the rocks in its bed and the extreme violence of the stream. After flowing in a nearly due south direction to the northern base of the Buxa hill, the river turns abruptly to the eastward, and again resuming its original direction makes its way to the plains, and under the name of Gudadhur falls into the Burhampooter river about 12 miles below Rangamatty."

From the Giâba La pass, 9,800 feet, a very fine view was obtained of the Kulha Kângri and Chhumolârhi snowy group of mountains. The highest of this group called B by Mr. Lane was fixed by him in 1860 from stations of the Eastern Frontier Series, distant nearly 190 miles to the south-east. In 1884 Mr. Robert obtained cross rays to it from stations of the Assam Longitudinal Series, distant about 140 miles to the south-west; and the combined observations have secured the position of the peak very accurately. The resulting height, 24,740 feet, is perhaps true within 100 feet or nearer. This imposing mass of snowy mountains forming the northern boundary of Bhutan constantly attracted the attention of Captain Pemberton's party who called them the Gassa range: R. N. heard no such name applied to them, and as Gassa means simply encamping-ground, Pemberton is probably in error.

Owing to disturbances in Bhutan, R. N. was forced to relinquish the idea of striking across the country in a course south of and parallel with Pemberton's route. He therefore had to leave the hills at Baxa Duâr Fort and re-entered them again at Dewangiri, the starting point of Pemberton's route through the Eastern Himalayas. Dewangiri is still practically a Bhutanese possession, where about 50 families of Duk Pa reside permanently. During the cold weather the Shingmis of Kurmed and Kurted bring their flocks down from the highlands to graze, when the place becomes of some little importance.

From Dewangiri up to the Diri Chhu, R. N. did not follow the old British military road, but travelled along the usual trade route. Signs of the Bhutan war are still evident in Kurmed, where old deserted terraces and ruined houses were frequently met with, and the military roads made by our forces between the Diri Chhu and Dewangiri may still be traced.

The party crossed the Dângmâ Chhu river at Denma Sanpa, a substantial chain bridge about 350 feet long said to be of great antiquity. A figure of the maker is carved in relief on the stone face of the tower at the Indian end of the bridge, and this personage, by name Chabdong Nawang Namgyal, has now become an incarnation. The head of the Tashi Chhu Jong Monastery takes this title which is not hereditary. A curious custom mentioned by R. N. in connection with the Tashi Chhu Jong Monastery may here be noted. The priests who are in charge of the monasteries on the pilgrim's road which encircles Kailas Mountain in Western Tibet are supplied from this remote place in Bhutan.

Pemberton crossed the Dângmâ Chhu river at Tashigong or Benkar and under the name of the Monas, thus describes it:—

"The Monas river, which at Tassgong or Benkar is called the Goomaree, appears to be the most considerable of all those which flow through Bhutan and receives either directly or indirectly the contributions of every minor stream which flows between it and Tongso. It is unfordable in any part of its course between Tassgong and its confluence with the Burhampooter river; and is crossed at the western foot of the Tassgong hill, by an iron chain suspension bridge of a structure almost exactly similar to those which have been so accurately delineated by Lieutenant Davis in the work of Captain Turner; * * * *
The valley through which the river flows runs nearly due north and south * * * *
The breadth of the river at Tassgong is about 60 yards and its waters rush with irresistible fury and a loud noise over a bed composed of boulders and highly inclined strata of gneiss. * * * The

precise situation of the sources of this river appears to be unknown in Bhutan, but it is described as beyond the northern limits of that territory * * * The length of the course of the Monas from Tassgong to Jugigopa, the point at which it flows into the Burhampooter, may be roughly assumed at 121 miles, and as the level of this part of the plains is about 148 feet above the sea and that of the bed of the Monas below Tassgong not far from 1,900 feet, the total distance, divided by this difference of level of 1,752 feet, will give a fall in the bed of 14½ feet in a mile, which at once accounts for the extreme violence of its current, and the accelerated velocity with which it rushes into the Burhampooter, where this latter river has fallen to its lowest level. The inhabitants of that part of the country through which the Monas runs, in speaking of it, invariably allude first to the extreme violence of its stream, which they represent as quite impracticable for even light canoes, a very short distance within the lower ranges of the hills."

A confirmation of this description is given by the explorer in his narrative. On attempting to cross the very long chain bridge over the Dángmá Chhu which was here found to be about 300 feet wide, the party were promptly stopped and a short altercation ensued with the guard, whereupon R. N. happily thought of the passport he had procured, which here for the first time and hereafter on other occasions proved of talismanic service, for the barrier of opposition was immediately removed and the whole party allowed to proceed unmolested.

I must here note an extraordinary omission made by Pemberton in his description of the chief rivers of Bhutan. He makes no mention of the Kuru or Lama U. G.'s Lhobra (written Lhobrak in Tibetan), which now proved to be the largest in the country. R. N. describes the Kuru as being of far greater volume at Kuru Phasam than Pemberton's Monas at Denma Sanpa. The former receives the drainage of the tract between the Yamdok, Pho Mo Chang Thang, and Tigu lakes in Tibet, and of the glaciers of the Kulhá-Kángri and other great ranges, and the latter, though it drains a large extent of country, apparently is not fed by glaciers, proved by the fact that while the water of the Kuru was muddy, that of the Dángmá Chhu was so clear that the stones could be seen in deep water. Part of Pemberton's account of Bhutan appears to have been written from memory, for he describes the chief trade route from Bhutan to Lhasa as lying up the Goomaree, whereas Lama U. G. found no such practicable route branching off from any point east of the Monla Káchung La pass. Pemberton's map gives only a course of 10 miles to the Lhobra above Lingtsi Jong, where he crossed it, whereas its source is shewn by the Lama to be a good 80 miles above that place; and until the exploration of Lama U. G. all geographers followed Pemberton's mistake.

The tract between the Diri Chhu and the Thungsi La pass is occupied by a tribe called Chingmi, described by R. N. as a mixed race—half Bhutanese and half Men. They occupy Kurmed and Kurted, Men Chhuna and Men Táwang, and extend as far east as Gyala Sindong and Pemakoi. Their language, called Shimkye, is said by R. N. and K. P. to resemble to some extent that of the Abors below Pemakoi on the Sangpo.

The Chingmis are of amiable disposition, living in houses of better construction than their Bhutanese neighbours. The men wear no dress distinguishing them from the Bhutanese, but their women resemble in appearance and in the cut of their garments those of Garbiang in Kumaun. Unlike the Bhutanese, both sexes wear pigtails. In the whole of the Chingmi country the Bhutanese form the official class.

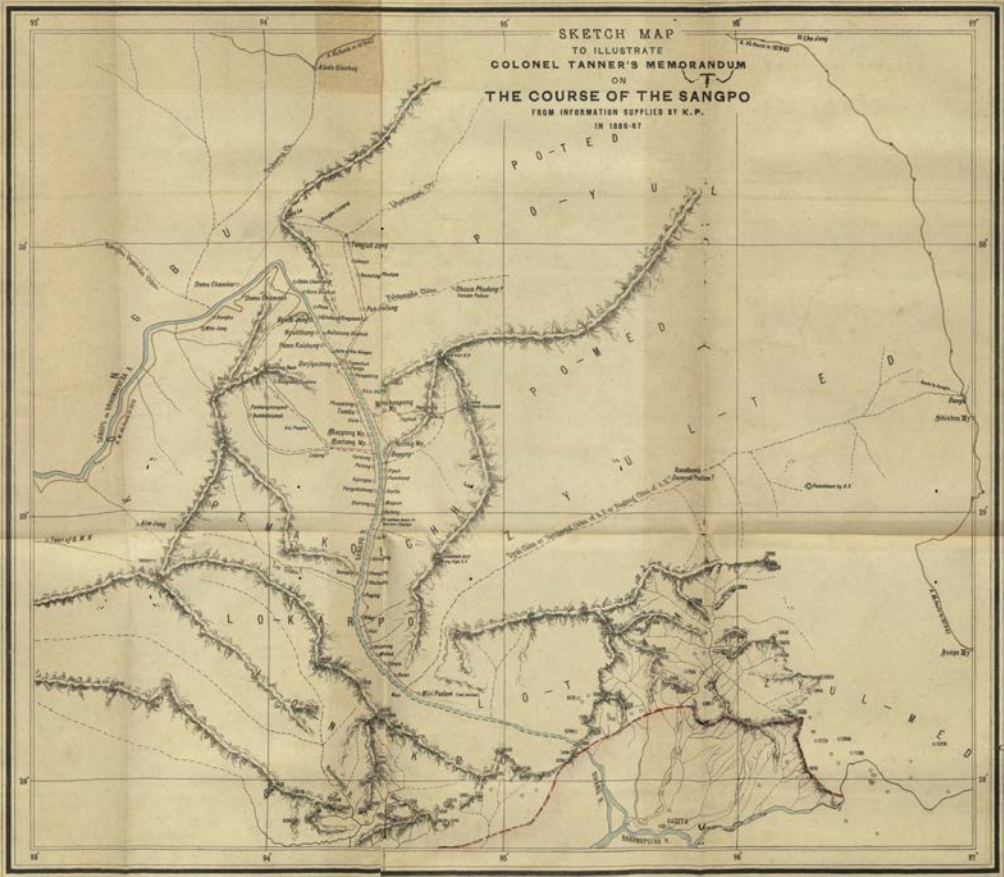
R. N. crossed the north-western border of the Chingmi country into that of the Bhutanese or Duk Pa at the Thungsi La pass (12,500 feet) whence a splendid view of the great snow peaks of the Kulha Kángri group was obtained. To the west the panorama of snowclad mountains extended to Chhumolárhi, but Kanchinjinga was unfortunately veiled in mist. To the east and north-east the snow peaks were unimportant. The position of this pass was fixed by magnetic bearings taken to Chhumolárhi and Kulha Kángri (B of Messrs. Lane and Robert). The sketch made by R. N. shows the position of the Monla Káchung La pass, which, as far as I can ascertain, is one of the most important on the common boundary of Bhutan and Tibet.

Biáka Jong (Beyagur or Juggur of Pemberton) on the Pumtháng river struck R. N. as being the finest fort he had seen anywhere. It is situated on a commanding point two or three hundred feet above the river with which it is connected by a covered way. The inhabitants are mixed Tibetans, Chingmis and Bhutanese, who carry on a considerable trade with Tibet and India.

The Pumtháng valley, by R. N.'s account one of the pleasantest in Bhutan, commences above Biáka Jong. It has much open cultivated ground and the altitude of the lower section is such that the climate is all that could be desired. The higher slopes are either dotted with *Abies Webbiana* or *Dumosa*, or have clumps and groves of those trees. At a lower altitude *Pinus excelsa* occurs. *Yaks* and all domestic animals are in plenty, and game abounds. Cross breeds called *Gyasa* are found in the forests of Kurmed and Pumtháng. The *shao* or great stag of Tibet was not heard of south of the Monla Káchung La pass, but the animals common to the higher regions were plentiful.

R. N. fixed the position of the Monla Káchung La pass (17,500 feet) by observations to Kulha Kángri, and then ascending into Tibet joined the traverse of Lama U. G. at Se, where the usual barren country always found in more elevated Tibet was reached. He found *phapar* (? oats) growing at an estimated height of 14,500 feet. This is probably the same grain that is met with in the most elevated cultivation in North Kashmir territory. The Duk Pa race extend northward to Se, beyond which the true Tibetans or Ped Pa occur.

The exploration ceased at Se Shangkar, and R. N. was obliged to make his escape from that place, and after a toilsome journey through Lhobrak crossed out of that



Surveyed under the direction of Colonel S. T. Haig, R.E., by Surveyor Bishop
Trigonometrical Branch, by Colonel H. H. H. Tanner, R.E., Asst. Superintendent, Survey

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Photolithographed at the Trigonometrical Branch Office, Dehra Dun.

Scale 1 inch = 12 Miles

Engraving by Mr. G. M. E. Atkinson
Do. Shading by Mr. H. Bishop
Typing by Mr. G. W. A. Atkinson

NOTE.—The routes along which K. P. has supplied information are coloured red.
Additional routes previously explored are coloured burnt-sienna.
Probable or approximately surveyed routes thus .....
Most heights being given thus .....

region by a high pass and eventually reached Men Táwang, crossing the Tashiyáng Chhu and Dozam Chhu *en route*, travelling the whole distance from the border of the Lhobrak country through a desolate high region inhabited only in favourable seasons by shepherds.

R. N.'s notes on the people of Bhutan together with a short vocabulary of the Chingmi language by Lama U. G. is given at the end of this memorandum. The Chingmis are not mentioned by Pemberton, nor have I seen the tribe noticed in any of the existing reports on Bhutan. The Ha Pa of R. N. cannot be identified with the Rangtang or Tebula of Pemberton's fifth and seventh classes, though from the position of Sanglah in Western Bhutan, R. N. states his opinion that the Sanglah and Ha Pa may be identified.

The Chingmis were met by K. P. in and around Pemakoi and by Lama Serap Gyatsho, a Mongolian Lama, who resided many years on the Lower Sangpo, whose account of Pemakoi together with K. P.'s narrative will be published hereafter.

In July 1880 a Chinese *lama* of Giardong was despatched by the late Captain Harman from Darjeeling to Tibet with orders to explore the country below Gyala Sindong and trace the great Sangpo to the plains of India, or failing this, to throw marked logs into the stream at the lowest point reached. It was intended that due notice should be given by the Lama to Captain Harman of the period during which the logs were daily to be cast into the river, so that he might set watchers at the place where the Dihang (Dihong) debouches into Assam, and thus prove the identity or otherwise of the great river of Tibet with the Brahmaputra.

K. P., a native of Sikhim, who had previously accompanied the explorer G. M. N. to Gyala Sindong and who has since traversed Bhutan with R. N.'s party, was sent with the Chinese *lama* as assistant, and his narrative shows how the proposed arrangements for casting the logs into the Sangpo fell through owing to the delinquency of the *lama*, who having sold K. P. as a slave in the Pemakoi country, decamped to his home in China.

K. P.'s narrative was taken by Lama U. G. as dictated to him by that individual, and the explorer states that the dates and distances given may be relied on as fairly true. He has been cross-questioned and examined by myself regarding his statements, and I have no doubt that his account is a *boná-fide* story of his travels. Lama U. G. and R. N. place complete reliance in K. P.'s statements, the outcome of which may be briefly summed up in a few words. K. P. reached Onlow or Onlet a short stage from Mir Padam, or Miri Padam, a village situated on a *dun* or plain on the Sangpo, a resort of traders from Assam, and the abode of the Miri and Padam tribes, who are known to ourselves to inhabit the country near the place where the Dihang breaks through the hills into Assam. K. P. was informed at Onlet that Miri Padam was about three days' journey or 35 miles from the nearest plains of India. K. P.'s sketch of the Sangpo from Gyala Sindong to the plains placed Miri Padam 24 miles east and a little south of the position in which it will be found on the sketch map accompanying these notes. After the sketch maps had been made by Lama U. G. we discovered in the records of the Assam Survey Party three plane-table sections by Captain Harman of the country adjacent to Sadiya which appear to give the junction of the Dihang with a large river coming from the north-east, and this large river I have assumed to be A—K's Nagong Chhu or K. P.'s Yangdong or Zyul Chhu. The general direction of the Sangpo for many miles of its course, as estimated by K. P., agrees very nearly with that of the Dihang as estimated by Captain Harman, and these two authorities are considered sufficient to authorise the alteration of the course of the Sangpo as given on the map accompanying the report on A—K's explorations to that shown on the annexed sketch map.

Mr. Needham, the Political Officer at Sadiya, writes to me that he has never heard of Miri Padam, but that the most northerly abode of the Abors who call themselves Padams, is "at Damroh Padam, situated north and a little east of Sadiya just behind the first high range of mountains." By adopting this position, Damroh Padam on the new map would be rather high up on the Yangdong river unless K. P. and Captain Harman are altogether wrong in the course they assign to the Sangpo. The explorer, however, says that he is quite certain that the haze of the plains of India was seen from Onlet in an easterly direction when looking down the river.

The Lharingpoi river is shown on the map accompanying the report on A—K's explorations (under the name of the Kongbo Giámdá Chhu) as entering the Sangpo at the corner of the great bend above Gyala Sindong, but K. P. and G. M. N. both agree in making the junction many miles lower down at Pango. The Kongbo Giámdo is said by A—K to join the Sangpo 20 miles above Gyala Sindong,* and the junction has now been made opposite Kongbu, where Captain Harman shows a large river coming in from the north. The great bend of the Sangpo was visited by G. M. N. who makes no river enter the Sangpo at that point, A—K's information regarding the junction of the Kongbu Giamdo with the Sangpo is therefore probably at fault.

K. P. describes the falls of the Sangpo below Pemakoi as a cascade of some 150 feet in height, and mentions the prismatic colours of the spray hanging over the dark basin or lake below the cliff. This rock is called Sinje Shejal, where there is a shrine.

The Chingmis mentioned by R. N. and an admixture of Tibetans occupy the Pemakoi Chhu tract, which extends to Dangam below which Tibetan names and Tibetan influence cease. Below Dangam the people are called Lo or 'utterly barbarous'.† There is no restriction to travel in the Lo country till Miri Padam is reached, beyond or to the

* The position of Gyala Sindong must be accepted with great mistrust. G. M. N.'s traverse "ends in air" and he is not an entirely trustworthy explorer.

† Not Lho as stated by A—K, which means 'south.'

Indian side of which no one appears to be allowed to cross from the Tibetan side. There is some confusion regarding the southern limits of the Po or Poh country which appears to join the northern boundary of Pemakoichhen. Po is managed by a council of Elders. The Raja of Poyul lives at Kanam in a palace called Shawa Phodang. Lama Serap Gyatsho mentions that the authority of this Raja has now become nominal only.

The Pemakoichhen district ceases at Dangam, whence the country of the independent and "quite barbarous" Lo Karpo commences. Tibetan names of villages and Tibetan influence cease at Dangam. An examination of the words in the short vocabularies of the Po, Lo and of the Chingmis might serve to identify these tribes under the names by which they are probably known to our officials in Assam. K. P. is the authority for the three lists given, and with slight errors they may perhaps be correct. The word "Chingmi" has only once come before me—it is affixed to a village of that name in Bhutan on the map of Bhutan, dated Calcutta, November 1874, and falls in the Chingmi country. The late Sir C. MacGregor is the authority for most of the new work that appeared on that edition, and to the Quartermaster-General's Department is due the credit of unravelling to a certain extent the great confusion which previously existed in the delineation of the course of the chief rivers of the country.

R. N.'s and K. P.'s narratives afford a considerable addition to our knowledge of the great unknown tract which surrounds the holy shrine of Tsari, which is said by K. P. to be situated on a ridge which discharges its drainage partly into the Lo river and partly into a river which flows into India; it is some 30 or 40 miles south of the Sangpo. This tract extends to the Sangpo on the north, India on the south, the Pandit's route to Men Chhuna on the west, and the Lower Sangpo on the east, and it seems very desirable that in the interests of geography we should not rest satisfied with the limited extent of our information of a country which lies so close to our doors.

The explorer R. N. made notes of the manners and customs, &c., of the people of Bhutan, and perhaps it would not be amiss to enter here what he noticed, though withal they be but fragmentary and meagre.

The Bhutanese, whether of high or low station, when on a journey, are never without a long sword of native manufacture, three wooden cups packed one within the other, and all put away in the breast pocket, and a handkerchief. The majority of the people are given to drinking intoxicating liquors made from different kinds of grain; they are also much addicted to eating the betel-nut with *pán*, and also chillies in large quantities. As a rule, they are all bad-tempered and are easily provoked.

On the occasion of a feast given by the Deb Raja, all below the rank of Jongpons are obliged to eat outside the palace, but those above that rank and of that rank are entitled to partake of the feast seated in the royal presence, squatting on terraced platforms, and each with those of the same rank, not promiscuously.

On the occasion of the Deb or one of the powerful chieftains travelling in the country, the news is sent along the line to be travelled over, and all villagers *en route* are compelled to burn fires to purify the air, as well as scented wood, so that the olfactory nerves of those dignitaries may not be offended by any malodorous exhalations on the roadside. Long processions are formed by their retainers, and this is the order of march observed on such occasions: first pass on the luggage carriers, then soldiers in various-coloured clothes, then follow the flagbearers and fife and drum players and beaters, then a long string of horses and mules richly caparisoned, then the *sinkaps* or lower officials, then two buffoons in gay attire with gaudy-coloured silks follow capering, dancing, and beating small drums, and then follows the Raja or chieftain, and after him a large following of *sinkaps* and others. When arrived at any place of importance small ordnance are fired off in honour of the traveller.

The *lamas* of the country wear caps, while all others wear *pagris*. Shoes of leather attached to long gaiters or stockings of wool are what are worn in the country. The males of the country wear their clothes only down to the knees, and ornaments are eschewed by the male population. The females wear their clothes down to the ankle and are very much given to ornament wearing. Both men and women as a rule shave their heads. Women enjoy perfect freedom in their movements and are not kept indoors.

Marriage ceremonies (where money is spent) are confined to the richer portion only of the population. Children are betrothed in many cases in early infancy, and the father of the bridegroom elect is expected to give money in proportion to his rank and means, and that of the girl betrothed. Sometimes as much as the equivalent of ₹800 is given. With this money jewels and clothes are purchased, and the girl is adorned with them, and then sent to the house of the parents of the boy. The women, who inhabit the tract known as Chingmi, dress differently from their sisters of Western Bhutan and do not shave their heads, but wear their hair.

Guns—muzzle-loaders—are manufactured in Bhutan as well as imported from Nepal. Flintlocks as well as percussion cap guns are used. The native-manufactured swords are formed of highly tempered steel and are very pliant. The shields of the country are proof against guns of local manufacture. When two powerful chiefs are at open feud with each other, they as often as not stake their respective claims on the issue of single combat.

Polyandry, since the days of Captain Pemberton, has been very largely on the decrease and can no longer be said to be a favourite custom in Bhutan.

The villagers in the country are taxed in local produce for the support of the Government. Bridges and roads are constructed and maintained by the villagers in the locality where they exist, the Government furnishing the implements only.

There is no gold currency in the country, only silver and copper coins circulate in Bhutan; portion of it is coined by the Government, and a large quantity of Tibet coin is in circulation also.

The chief monasteries in Tibet are:—

(1) Daiphung containing 7,700 priests, who wear yellow caps.
(2) Serâh " 5,500 " " " " "
(3) Gâdin " 3,300 " " " " "
(4) Sâkya, number of priests not ascertained; they wear red caps.
(5) Samiye " " " "
(6) Tashilhumpo containing 2,000 priests, who wear yellow caps.

The chief monastery in Bhutan is Tashichhujong, containing 300 priests, from whom the chief *lama* of the Kailâs monasteries as well as all the *lamas* for all the principal ones in Bhutan are chosen. In all the chief monasteries in Tibet and Bhutan, all the priests wear red frocks or gowns, and the cap is a distinctive badge of the monastery to which they are attached. There are certain officials who have particular duties to perform. The following enumerates the officials and their duties, *viz.*,—

(1) Chief *lama*, over all others.
(2) *Dorjelopan*, sacred interpreter.
(3) *Uje*, leader in prayers.
(4) *Chhûtimba*, moderator, monitor, and responsible head.
(5) *Chinyer*, treasurer.
(6) *Kunyer*, image-keeper and protector.
(7) *Tenyur Yarpa*, keeper of the sacred records.
(8) *Chabdil*, holy water distributor.
(9) *Tungpa*, conch blower to summon priests to prayers.

The modes of salutation in Tibet and Bhutan are curious if not ludicrous; they are as follow:—

The Tibetan mode of salutation to a superior is in taking off the cap from the head and protruding the tongue and then backing a few steps; it is called "*chabul.*"

The Bhutanese fling a strip of several yards of narrow silk (2 feet wide) to their superior, retaining one end in hand, the other end is then held by the person honoured, and after a short interval the whole strip is withdrawn; this is termed "*tharta.*"

All nuns in Tibet and Bhutan are called "*auni,*" and when they meet each other shake hands in salutation; this is called "*gori.*"

Priests remove the red *chaddar* from their shoulders and present it to the person saluted; this is known as "*senkhe.*"

The seven largest rivers in Bhutan are the following: Ammo chhu, Kuru chhu, Dángáma chhu, Pumthâng chhu, Tongsa chhu, Wong chhu, and lastly the Di chhu.

The Pho chhu is not inconsiderable and may well be added to the above seven, making the eighth.

Vocabulary of the Chingmi (Tshingmi) language written in Tibetan by Lama U. G. and translated by explorer R. N. and Norpu.

English.	Chingmi.	English.	Chingmi.
I	Chang.		
You	Nán.	*Numerals.*	
Here	Thâh.		
What	Hang.	1	Thoor.
Good	Lekpu.	2	Ngik tsen.
House	Phâika.	3	Sa-um.
Butter	Si.	4	Fee.
Road	Lom.	5	Ga.
Rice	Khu.	6	Khung.
Little	Ta Sir.	7	Zum.
Salt	Encha.	8	Yen.
Marwa (beer)	Yu.	9	Gu.
Stay	Chhoinâ re (?).	10	Sey.
Pounded maize	Pharang.	11	Song Thoor.
Man	Song.	12	Song Ngiktsen.
Go	Dighee.	13	Song Sa-um.
Drink	Chamshu.	14	Song fee.
Buy	Ngo na.	15	Song ga.
Slowly	Ngu dung.	16	Song khung.
Water	Jum (?).	17	Song zum.
		18	Song yen.
		19	Song gu.
Pemakoi dialect of Chingmi.		20	Khay Thoor.
Cow	Big.		
Little	Dah.		
Water	Tsi.		
Cooked rice	Khwen Kharang.		
Cooked maize	Ashum Kharang.		

Vocabulary of the Chingmi language.

English.	Chingmi.
Where are you going	Nan o di le ya.
I am coming here	Chang thah ou pha ya.
What is your name	Nan ka ming hang duk pa ya.
My name is Kintub	Chang ka ming kuntub duk pa ya.
Now you stay here (ordinary)	Nan chhui na roh.
Now you stay here (respectful)	Nan chhui sukchu na.
Now you stay in sound health (respectful)	Nan leg pu chhui Naro.
I am going to my house	Chang phayi ka dilay.
Please lend me a house	Chang ka phayi thur nga bedong.
I will stay here	Chang thah chhoi lay.
Have you got rice	Nan ka khu chakka moh.
Kindly sell some rice for me	Changkha khu dah sir Tshonginoroh.
What price do you want for it?	Nan rin hanga le mo.
I want some salt as the price of it	Chang ka rin enchaga lay.
Wait a little and I will give you some *marwa* (beer)	Nan da sor chhoina jong you bidong.
Sit and you stay here (farewell-respectful)	Nan leg pu chhoi Naroh.
Will you take rice?	Nan kharang sa lay mo.
Will you drink water	Nanri jum lay mo.
I won't take rice but I will eat some flour	Chang kharang mi say bok bi sa lay.
I won't drink the *marwa* of maize	Chang a shom u man jam pa la.
I will drink *marwa* (beer)	Kongbu u jam bey.
Have'nt you got butter	Nan ka sima-lah mo.
Will you drink tea	Nan chae jam be mo.
Have you got tea?	Nan ka chae chakka mo.
I have got (some) tea	Chang ka chae chakka ya.
Bring it here and I will drink	Thah phaye jing jam dong.
You had better sleep here	Nan thah yikchu lay.
Don't tell a lie	Nan zoma yikchu na roh.
You must speak properly	Nan koku lekpa yikchu lay.
Shew me the road	Chang ka lom tonchu na roh.
I don't know this road	Tah ka lom changma siwa la
Please let me go	Chang ka thah chhuna.
There is not a good road	Tah lom leg pu ma lah.
The road was broken by the slip	Lom chakpa kyab pa lah.
I don't know everything	Chang hang rang ma siwa la.
I know	Chang siwa la.
Am coming	Oo phaya.
Will go	Di leya.
What says	Hang tak paya.
Sit here	Chui Naro.
Lend me	Nya bi thong.
Will give	Bi dong.
Sit for a moment	Da san (?) chhona.
I have an uncle, so I am going to visit him	Chang-yohu-aku-thur chaka yu aku, rum ka thile.
Will you buy salt?	Ancha ngo leu mo.
What will you take in return for the salt?	Ancha ku rin hung-gale mo.

(Meaning / Farewell)

NOTE.—Some give nam instead of nan for the interrogative.

Vocabulary—A few sentences of the language of the Kham Pobas who inhabit the tract called Po between Pema Koichhen and the Province of Kham.

English.	Kham Poba.
Have you come back?	Ya khore kyo gyosin.
What have you to say?	Kyo chi dzo gyu yole re.
I have come to see you to-day.	Nga thasong kyo ser shaong le yi.
Are you well?	Kyo kutsi nyungshi tang bu a yo.
Yes, I am quite well.	Tha, song nga khum zung bu yo.
Sit a little.	Yo rang seng tso duk.
I have no time to sit, I have to go somewhere.	Tha song nga duk long me, nga ána sha-do-gole da
Where have you come from?	Khyo tha song-ghale-ongle yi.
Where are you going?	Khyo Gha-sha do-gyu-yi.
What do you want?	Khyo chi-gole yi.
What is the name of this place?	Konyu the ningla chi dzo le-yi.
Is there a road there (to that place)?	Ana lum yole ayi mi-la-yi.
Bring a cup of water for me.	Nga la tha-song chhu phorba ghangbinle.
Bring my horse.	Ya khore ta ti-sho-ogo.
Put the saddle on the horse.	Ya tchga yamu tsuk-tang ogo.
Light the lamp.	Koré la-ong-chik pago le-du.
Is there a bridge over the stream?	Kore chhu-chen the-la sumpa yole áda.

This language differs slightly from Tibetan. NOTE.—Khyo is written kho by some.

Vocabulary—A few words of the language of the Lobas (the Lo Karpo, Lo Nagpo, and Lo Tawa), who inhabit the Lower Sangpo south of Bepung.

English.	Loba.
Cow	Bha-mon.
Water	Amish.
Fire	Ashish.
Hog	Marshu shu.
Food	Dokay.
Wine (beer?)	Apongshi.
Sit	Dolengka.
Go	Kaju.
Come	Sha.
Name	Mirangka.
Hand	Alak.
House	Earangshi.
Stream	Amish.
Eye	Amik.
Cotton	Opot.
Copper vessel	Shang goshi.
Salt	Aloshi, Ancha.
Sun	Donyi.
Moon	Polok.
You	Noshi.
Eat	Dolama.
Bring	Lato mepa.

There are no horses, mules or asses in the Loba country.

DRAWING OFFICE, CALCUTTA.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

Statement showing the work performed during the year 1886-87.

TITLE OF MAP.	Number of Sheets.	Scale. I. M.	REMARKS.
General Maps.			
India. Engraved	6	1 = 32	Additions to date.
Do. Ditto	4	1 = 64	Changes to boundaries and additions to Railways up to date.
Do. In relief	...	1 = 32	Cast in Plaster of Paris.
Do. Lithographed	6	1 = 32	New edition.
Do. Contour	6	1 = 32	Corrected for lithography.
Do. Military	6	1 = 32	Showing all military stations and cantonments with railway lines, large rivers, and towns; published.
Do. Skeleton	2	1 = 64	Showing only district boundaries corrected to date; published.
South-West Asia	6	1 = 32	Outlined and shaded in England, names and sites being inserted from most reliable sources. The sheet in hand takes in Teheran, Mashhad, Astrabad, and Ispahan.
Afghanistan	4	1 = 24	South-East section in hand.
Atlas Sheets.			
Nos. 11 S. E., 14 S. W., 15 N. W., 21 S. W., 23 S. E., 23 N. E., 35 S. W., 36 N. W., 37 S. W., 42 S. E., 48 S. W., 50 S. E., 50 N. W., 57 N. W., 57 S. W., 77 S. W., 78 N. W., 88 N. E.	...	1 = 4	Outline and names for engraving.
Nos. 12 N. W., 14 S. E., 15 N. W., 19 S. E., 20 S. E., 23 S. E., 30 N. W., 36 S. W., 37 N. W., 38 N. W., 42 S. E., 43 N. W., 43 N. E., 50 N. E., 60 N. E., 61 N. E.	...	1 = 4	Hills brush-shaded for engraving.
Nos. 114 S. W., 114 S. E.	...	1 = 4	For heliogravure; published.
Nos. 14, 119, full plates	...	1 = 4	Additions to railway and change of boundary.
Provincial Maps.			
Mysore State	1	1 = 16	Without hills, published by photozincography; will eventually be engraved on copper.
Upper Burma	1	1 = 16	Without hills, compiled from Captain Hobday's 4″ reconnaissance sheets; published.
Ditto	1	1 = 16	With hills, compiled from Captain Hobday's 4″ reconnaissance sheets; published.
Rajputana Agency	2	1 = 16	Unsurveyed portions about Jeysulmere completed from best available materials and lithographed; published.
Gujarat	1	1 = 16	Compiled from 1 and 2-inch surveys, brought up to date; is being engraved.
Punjab and its dependencies	4	1 = 16	Corrected according to instructions received from the Punjab Government; is being engraved.
Province of Assam	1	1 = 16	Additions to date from recent surveys.
Divisional Maps.			
Burdwan	2	1 = 8	Compiled on the 4-inch scale from latest materials for reduction to one-half; drawing finished.
Patna	8	1 = 8	
Bhagalpur	2	1 = 8	Compiled on the 4-inch scale from latest materials, for reduction to one-half; drawing in hand.
Rajshahi	4	1 = 8	
District Maps.			
Darjeeling	1	1 = 4	Being compiled from recent 2-inch surveys, in hand.
Cachar	1	1 = 4	Prepared for lithography by transfers from copper and corrected to date; in hand.
Nowgong	1	1 = 4	
24-Pergunnahs	1	1 = 4	
Khoolna	1	1 = 4	
Chumparun	1	1 = 4	
Burdwan	1	1 = 4	
Jubbulpore	1	1 = 4	

DRAWING OFFICE, CALCUTTA.

SECTION I.

Statement of work—continued.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS.
		I. M.	
District Maps—continued.			
Nuddea	1	1 = 4	Corrected to date and sent to Lithographic Office.
Khoolna	1	1 = 4	
Jessore	1	1 = 4	
Sonthal Pergunnahs	1	1 = 4	
Moorshedabad	1	1 = 4	
Sarun	1	1 = 4	
Standard Maps.			
UPPER BURMA (N.E. TRANS-FRONTIER SERIES)—Sheets 15 S.E., 15 N.E., 23 S.W.	...	1 = 4	Compiled by Captain Hobday *from* surveys, reconnaissances and local information. Names printed and maps finished in Drawing Office; published.
UPPER BURMA (S.E. TRANS-FRONTIER SERIES)—Sheets 1 N.E., S. E., 2 N. E., S. E., 4 N. W., S. W., 5 N. W., S. W., 6 N. W.	...	1 = 4	
CENTRAL INDIA & RAJPUTANA—	483	1 = 1	Marginal sheets being completed.
Sheets 367, 400, 401	...	...	Published.
„ 385, 386, 388, 402, 403, 404, 405, 415, 416, 417.	...	...	In hand.
NORTH-WESTERN PROVINCES & OUDH—	221	1 = 1	
Sheets 56A, 56B.	...	...	Published.
BOMBAY— Gujarat	63	1 = 1	Drawn for reduction to 1-inch scale.
Sheets 119, 214, 216	...	...	Completed heading, foot-notes, references, &c.; published.
Cutch	37	1 = 1	
Sheets 52, 53, 70, 71	...	...	Completed heading, foot-notes, references, &c.; published.
Administration Report Maps.			
BERAR ASSIGNED DISTRICTS—Ellichpur, Amraoti, Akola, Basim, Buldana, Wun.	6	1 = 8	
COORG	1	1 = 8	
CENTRAL PROVINCES—Chanda, Bastar, Wardha, Chhindwara, Saugor.	49	1 = 8 and 1 = 16	
PUNJAB—Kohat, Dera Ismail Khan, Delhi	31	1 = 8	
BENGAL—Hill Tipperah, Manbhoom, Durbhunga.	48	1 = 8	
RAJPUTANA—Ajmere, Merwara.	2	1 = 8	
NORTH-WEST PROVINCES—Garhwal, Fatehpur, Ghazipur, Merwara.	37	1 = 8	
OUDH—Sitapur, Fyzabad, Hardoi, Kheri.	11	1 = 8	

DRAWING OFFICE, CALCUTTA.

SECTION I.

Statement of work—continued.

Title of Map.	Number of Sheets.	Scale.	Remarks.
		I. M.	
ASSAM— Garo Hills, Khasia and Jaintia Hills, Lakhimpur.	11	1 = 8	
Index Maps.			
Standard sheets, Bombay Presidency	1		
Standard sheets, Sind	1		
" " Madras Presidency	2		
Standard Sheets, Burma	2		
Reconnaissance Sheets of Burma	1		
Survey Operations in Mirzapur	1		
Ditto Madras	1		
Ditto Gujarat	1		
Ditto Baluchistan	1		
Statistical Maps.			
India. Tea	2	1 = 64	33 } copies coloured by hand from data supplied by Revenue and Agricultural Department.
Do. Jute	2	1 = 64	6 } copies coloured by hand from data supplied by Revenue and Agricultural Department.
Do. Coffee	2	1 = 64	11 } copies coloured by hand from data supplied by Revenue and Agricultural Department.
Do. Rice	2	1 = 64	Corrected and sent for chromolithography.
Do. Surgarcane	2	1 = 64	Ditto ditto.
Do. Railway feeders	6	1 = 32	} Additions and corrections up to date being made.
Do. Canals	6	1 = 32	} Additions and corrections up to date being made.
Do. Railways	6	1 = 32	Coloured and brought up to date for use of His Excellency the Viceroy.
Miscellaneous Maps.			
Western Afghanistan	1	1 = 24	Showing routes taken by Dr. Aitchison; drawn and original supplied to Foreign Office.
Burma	1	1 = 12	A tracing made for Foreign Office.
Central India	1	1 = 32	Specially prepared for Sanitary Commissioner, Central India; published.
Bengal, Behar, Orissa and Chota Nagpore	1	1 = 32	Specially prepared and original supplied to Sanitary Commissioner, Bengal.
Bengal, Behar, Orissa and Chota Nagpore	2	1 = 16	Specially prepared and original supplied to Sanitary Commissioner, Bengal; published.
China (skeleton) showing Customs and Treaty Ports	1	1 = 96	Prepared and original supplied to Revenue and Agricultural Department.
North-Western Railway	1	1 = 32	Prepared for the Manager of the North-West Railway, published.
Vernacular Maps of Northern Afghanistan	5	...	For Foreign Office; published.
Northern Afghanistan	2	1 = 8	Prepared for Captain Yates, showing his routes.
Hills around Naini Tal	1	1 = 8	Prepared as an index to Panorama of snows from Naini Tal.
Physical Atlas of India	21	...	Coloured for Foreign Office.
Boundary between Garo Hills and Mymensingh	2	2 = 1	Examined and corrected for reproduction by photozincography; published.
Jacobabad to Chaman and adjoining countries	1	1 = 16	Portions of Sheets $\frac{21}{22}$, + $\frac{19}{30}$ of North-West Trans-Frontier; published.
Guide map of Simla and Jutog	2	6 = 1	Corrected for second edition.
Skeleton Map of India	2	1 = 64	Specially prepared for Home Department.
Province of Assam	1	1 = 24	One copy for Revenue and Agricultural Department and one for Superintendent of Forests showing inner line of boundary of districts Darrang, Sibsagar, Lakhimpur, and Cachar.
Do. do.	1	1 = 24	Cholera map for Deputy Surgeon-General.
Trace of boundary between Sind and Marwar.	1	1 = 4	One copy for Resident, West Rajputana, and one copy for Deputy Commissioner, Thar and Parkar.
CHARTS— Triangulation Charts of Mysore	...	1 = 4	Four were completed by inserting latitude longitudes and azimuths; published.

DRAWING OFFICE, CALCUTTA.

SECTION I.

Statement of work—concluded.

Title of Map.	Number of Sheets.
Maps examined.	
General and Provincial Maps	29
Original Atlas Sheets or portions of sheets	40
Divisional Maps	2
District Maps	5
Original Standard Maps	87
Trans-Frontier Maps	9
Index Maps	5
Statistical Maps of India	38
Special and Miscellaneous Maps	54
Tracings of Original Maps	4
Engraved proofs of General and Provincial Maps	21
Engraved proofs of Atlas Sheets in various stages	123
Photo-Electro proofs of Atlas Sheets	5
Lithographic proofs of General and Provincial Maps including Index Charts	8
Lithographic proofs of Atlas Sheets and District Maps transferred from copper-plates	34
Lithographic proofs of Special and Miscellaneous Maps	41
Photographic proofs of Standard Sheets, Large Scale Plans, and various other Maps	297
Projection and Examination of graticules and plotting of points	25
TOTAL	825

N.B.—In addition to the above, many miscellaneous jobs such as tracings of charts, supply of geographical data to various officials calculation of areas, examination of the proof sheets of "Survey of India Notes" and of Narrative Reports of Survey Parties as to the correct orthography of names, &c., have been performed by the Examining Section.

DRAWING OFFICE, CALCUTTA.

SECTION II.—REVENUE.

Statement showing the work performed during the year 1886-87.

Title of Map.	Number of Sheets.	Scale.	Remarks.
STANDARD MAPS.		I. M.	
Punjab.			
District Hissar	14	1 = 1.	Drawn on the 2" scale for reduction by photography to the 1" scale.
Sheets 243, 244, 257, 258, 259 and 260	...	...	Final press order given.
Sheets 241, 242, 256 and 261	...	...	Marginal sheets completed and sent to press.
Do. do.	43	2 = 1	All published.
District Rawalpindi (Kahuta Forest)	42	4 = 1	
Sheets 160 ($\frac{N.E.}{2,3,4}$, $\frac{S.E.}{1,2,3,4}$), 161 ($\frac{N.E.}{1,2,3}$, $\frac{S.E}{2,3,4}$), 162 ($\frac{N.E.}{1,2,3,4}$), 183 ($\frac{S.W.}{3}$), 185 ($\frac{S.W.}{2,3.4}$), and 186 ($\frac{N.W.}{1,2,3,4}$ $\frac{S.W.}{1.2,3,4}$)	...	...	Fair sheets and proofs examined. Publication deferred pending settlement of Forest boundaries.
Sheets 160 ($\frac{S.E.}{2,3}$, $\frac{N.E.}{3,4}$) and 160 ($\frac{N.E.}{3}$, $\frac{S.E.}{2,4}$)	...	...	Proofs examined and sent to press for corrections and insertion of Forest boundaries supplied by executive officer.
Districts Jullundur and Ludhiana	12	1 = 1	Drawn on the 2" scale for reduction by photography to the 1".
Sheets 250, 251, 252, 253 and 268	...	...	Passed with final press order with the exception of No. 253 which is being completed up to margin.
District Delhi	7	1 = 1	Examined and final press order given for reprint.
Sheets 298, 299, 319, 320, 321 and 322	...		
North-Western Provinces and Oudh.			
Meerut Division	35	1 = 1	Drawn on the 2" scale for reduction by photography to the 1".
Sheets 23, 36, 37, 52 and 53	...	...	Marginal sheets completed and under examination. 30 sheets published.
Sheets 23 (N.E., S.E.), 36 (N.W., N.E., S.W., S.E.), 37 (N.W.), 52 (N.W., N.E., S.W., S.E.), 53 (N.W., N.E., S.W., S.E.)	119	2 = 1	Proofs examined. Publication deferred pending receipt of lists giving the correct spelling of village names. 104 sheets published.
District Gorakhpur—			
Sheets 191 (S.W., S.E.), 192 (N.W., N.E., S.W., S.E.), 206 (N.W., N.E., S.W., S.E.), 207 (N.W., N.E., S.W., S.E.), 208 N.W., N.E., S.E.), 216 (N.W., S.W.), 217 (N.W., S.W.)	16	1=1	Drawn on the 2" scale for reduction by photography to 1". Skeleton sheets showing trijunctions of villages were received during this and previous years. Portions of Sheets Nos. 192 N.W., 207 N.E., S.E., S.W. and 208 N.E. have been pentagraphed from the 16" plans and inked up. Nos. 216 and 217 have been drawn and completed. The latter is a marginal sheet.
District Mirzapur	18	1=1	Drawn on the 2" scale for reduction by photography to the 1".
Sheets 183	...	...	Drawn, examined and sent to Press.
Sheets 198, 199 and 212	...	...	Drawn and examined, awaiting completion to margin.
„ 169, 182, 184, and 197	...	...	Under examination.
„ 170 and 171.	...	...	In hand.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—continued.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS.
STANDARD MAPS—*contd.*		I. M.	
District Mirzapur—*contd.*			
Sheets 168 N.E., 169 $\left(\frac{\text{N.E.}}{\text{E.}}, \frac{\text{N.W.}}{\text{W.}}\right)$, 182 $\left(\frac{\text{N.W.}}{\text{W.}}, \frac{\text{N.W.}}{\text{E.}}\right)$, and 184 $\frac{\text{N.E.}}{\text{E.}}$	...	...	Field sections received from No. 14 Party to be incorporated with the 1″ standards.
Districts Benares, Ghazipur and Ballia	16	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 194, 208, 209, 217, 218, 219, 220 and 221	...	...	Examined with 16″ plans, corrected and press order given.
„ 195	...	...	Marginal sheet completed.
„ 210, 211	...	...	Examined with 16″ plans, corrected and sent to press.
„ 180, 181, 182, 196, and 197	...	...	Preliminary examination completed and under correction.
Oudh	65	1=1	
Sheets 86, 87, 116, 119, 122, 132, 133 and 134	...	...	Press order given.
„ 102, 104, 117 and 118	...	...	Sent to press for correction. 36 sheets published.
Bengal.			
District Cuttack	16	1=1	
Sheets 194, 195, 196	...	...	A portion of the district being specially drawn for the Irrigation Department. At present in abeyance.
District Jalpaiguri	14	1=1	Nine sheets published last year.
Sheets 293, 294, 315, 338 and 339	...	...	All published.
District Mymensingh, Nos. 343, 344, 345, 346 and 364.	23	1=1	Proof received from Press and sent to District officials for corrections and additions. No. 344 sent to press for omissions to be supplied.
Bombay.			
Konkan	...	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheet 160	...	...	Examined. Publication deferred until the portion of Dharampur State is surveyed, when it will be sent to the field party for completion.
Sheets 135 and 161	...	...	Press order given.
„ 134 and 168	...	...	Examined, corrected and sent to Press.
South Maratha Country	...	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 172, 173, 204, 275, 276	...	...	Examined, corrected and sent to Press.
„ 203, 238, 239 and 270	...	...	Press order given.
Burma.			
Districts Bassein, Henzada, Prome, Tharrawaddy, Hanthawaddy, Pegu and Shwegyin.	...	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 178, 179, 180, 181, 227 and 228	...	...	Drawn in this office, examined and passed with press order.
„ 140, 182, 183, 184, 185 and 186	...	...	Examined and press order given.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—continued.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS.
		L. M.	
Sheets 322, 323, 324 and 325 . . .	...	...	Examined and press order given, with the exception of No. 324 which awaits return of proof from District Officer.
„ 141 and 231	...	...	Redrawn and sent to Press.
„ 232	...	...	Redrawn and under correction.
PLANS OF CITIES, CANTONMENTS, &C.			
Benares City including Sikrol and Pandipur Cantonments.	4	8=1	Plotted and pentagraphed. Drawing of one section in hand. At present in abeyance.
Government Cattle Farm, Karnal . .	4	16=1	Final press order given.
INDEX MAPS.			
Standard Sheets, North-Western Provinces and Oudh.	1	...	Drawn and sent to Press.
Standard Sheets, Central Provinces . .	1	...	Ditto.
Do. do. Bengal	1	...	Ditto.
Survey Operations in the Punjab . . .	1	...	Ditto.
Cadastral Survey in District Bilaspur . .	1	...	Ditto.
Do. do. Tarai . .	1	...	Ditto.
Do. in districts Kamrup, Darrang and Nowgong.	1	...	Ditto.
Cadastral Survey in District Akyab . .	1	...	Ditto.
Do. in districts Bassein and Thongwa.	1	...	Ditto.
Survey of the Town of Calcutta . . .	1	...	Ditto.
Cadastral Survey in Sankarpur Estate . .	1	...	Ditto.
Do. do. in Angul Estate . .	1	...	Ditto.
Traverse Survey in Districts Seoni and Chhindwara.	1	...	Ditto.
Traverse Survey in Districts Saugor and Narsinghpur.	1	...	Ditto.
Sheets of the Hooghly River Survey . .	1	...	Ditto.
Examination of Proofs.			
Photo-zincographed maps	361		
Lithographed maps	38		

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—continued.

DESCRIPTION OF WORK.	REMARKS.
Computations examined.	
Districts Ajmere and Merwara, Seasons 1883 to 1886.	
District Benares, ,, 1882 to 1884.	
Traverse Data, &c., supplied.	
Oudh Forest, District Kheri	To Superintendent, Forest Surveys.
District Hanthawaddy along District Thongwa (12 pages).	To Deputy Superintendent of Surveys.
Bahawalpur State along Jacobabad and Rohri (28 pages).	For Superintendent, Sind Survey.
Main Circuit, Nos. 3, 4, 10 and 11, District Mirzapur along unsurveyed portion.	To Deputy Superintendent of Surveys.
Main Circuits, Nos. 2 and 3, District Bassein, along unsurveyed portion.	To Deputy Superintendent of Surveys.
48 villages of Mirzapur	Ditto ditto.
Certain Bombay villages	To Survey and Settlement Commissioner, Punjab.
4 villages	To the Collector of Patna.
8 ,, ...	Do. of Pubna.
7 ,, ...	Do. of Sarun.
3 Frontier Circuits of Sylhet	To Surveyor.
Triangulation data and description of G. T. S. along Sylhet and Tipperah boundary	Ditto.
Field Area Statement of 1 village, District Pegu .	To Superintendent of Survey and Registration.
Values and description of Level Bench-marks in Bahraich.	To Executive Engineer, Oudh and Rohilkhand Railway.
Latitudes, longitudes, and azimuths of Topographical Survey Stations in Raipur.	To Assistant Superintendent of Surveys.
Latitudes, longitudes, and azimuths of Topographical Survey Stations in Bilaspur.	Ditto ditto.
Latitudes, longitudes, and azimuths of Topographical Survey in Sambalpur.	Ditto ditto.
Alphabetical and statistical statement of Bhagalpur (28 pages).	To the Collector of Bhagalpur.
Miscellaneous.	
Preparation of a statement showing area and cost of all the districts and Native States in the Punjab.	For Secretary, Government, Punjab.
Preparation of a statement of Waste Land Blocks in Hoshangabad.	For Deputy Commissioner.
Computation of rectangular co-ordinates for the projection of Districts Bassein, Gonda and Sirsa.	
Computation and plotting for the settlement of disputed boundary between Bahawalpur State and Dera Ghazi Khan.	
Computation and plotting for a congregated map of certain villages of District Pubna.	For Collector of Pubna.
Preparation of area statement of District Mirzapur by perganas.	
Preparation of a statement showing area and cost of Districts Moradabad, Muttra, Agra, Hamirpur and Banda.	For Revenue Board, N. W. P.
Calculation of areas by *parganas* of 2″ sheets Nos. 3, 7, 23, 37, 183, 194, 208, 209, 210, 219, 220, and 221, N. W. P.; Sheets Nos. 241, 242, 243, 256, 257, 258, and 261, Punjab; Sheet No. 68A., Deccan.	
Preparation of tables and returns for Annual Report.	
Calculation of areas of offsets of the villages of Districts Ajmere and Merwara, as also preparation of Alphabetical Indexes, &c., &c.	In progress.
Revision of areas of Districts Bahraich, Gonda and Kheri according to present boundaries.	

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—concluded.

TITLE OF MAP.	Scale.	REMARKS.
Tracings.	I. M.	
Seven village plans of Pargana Chunar, District Mirzapur.	2=1	For Collector.
Sheets Nos. 11 and 12, Tahsil Gurgaon, District Gurgaon.	4=1	For Deputy Commissioner.
Sixty-two village plans of District Sarun bordering on District Gorakhpur, with index.	4=1	For Deputy Superintendent of Survey.
One village plan of Pargana Gayhutta, District Pubna.	4=1	For Collector.
Five village plans of Pargana Mulki and Ghiaspur, District Monghyr.	4=1	For Collector of Patna.
Skeleton tracing of portion of sheet 216, District Monghyr.	1=1	Ditto ditto.
One village plan of Pargana Nathpur, District Bhagalpur.	4=1	For Collector.
Boundary along unsurveyed portion of Colonel Anderson's work, District Mirzapur.	2=1	For W. H. Patterson, Esq.
Twenty-three village plans of District Sarun bordering on District Gorakhpur, with Index.	4=1	For Major Sandeman.
One village plan of District Sylhet .	4=1.	For Assistant Surveyor.
Sheets Nos. 6 and 7, District Gurgaon	4=1	For Deputy Commissioner.
Two village plans of Pargana Chunar, District Mirzapur.	4=1	For W. H. Patterson, Esq.
Five Cadastral plans of District Dehra Dun.	16=1	For Colonel Haig, Deputy Surveyor-General.
Portion of M. C. No. 30 D. Survey .	1=1	For Collector of Mymensingh.
Portion of Sheet No. 4, District Pubna.	1=1	Ditto ditto.
Seven villages of Pargana Esuphshahee, District Pubna.	4=1	For Collector of Pubna.
One village plan of Pargana Barabaju, District Pubna.	...	Ditto ditto.
Portions of Parganas Barabaju and Mehmanshahee comprising Thanah Sherpore, District Bogra.	1=1	For Magistrate of Bogra.
Portion of Sheet No. 168 S.E., District Mirzapur.	2=1	For W. H. Patterson, Esq.
Two villages, Ganges Deara Survey	4=1	For Collector of Patna.
Portions of Sheets Nos. 80, 83, 84 and 85 of District Bareilly bordering on District Tarai.	4=1	For Deputy Superintendent of Surveys.
Six village plans of Pargana Esuphshahee, Barabaju and Kagmari, District Mymensingh.	4=1	For Collector of Mymensingh.
Portion of map of District Pooree, season 1840-41.	1=1	For Collector.
Portion of maps of British and Native territories in Bundelkhand.	1=1	For Executive Engineer, Charkhari State.
Two village plans of District Umballa	4=1	For Settlement Officer.
One village plan of District Bhagalpur.	4=1	For Deputy Commissioner, Sonthal Parganas.
Eighteen sheets of Bahawalpur State along Sind.	4=1	For Superintendent, Sind Revenue Survey.
Parganas Gurla, Tarreya and Mokrunpur, District Goalpara.	2=1	For Deputy Commissioner.
Sheets 78, 79 and 80, District Karnal	4=1	For Superintending Engineer, Western Jumna Canal.
Sixteen sheets Ganges Deara Survey	4=1	For Superintendent, Way and Works, Eastern Bengal State Railway.
Sheets Nos. 231 N.W. and S.W., and 232 N.W. and S.W., District Henzada.	2=1	For Captain A. Carpenter, Marine Survey.

DRAWING OFFICE, CALCUTTA.

SECTION. III.—CADASTRAL.

State of Publication of Cadastral Maps on the 30th September 1887.

DISTRICTS.	NUMBER OF SHEETS.							REMARKS.
	MAPS PREPARED.			PUBLISHED.				
	Up to 30th September 1886.	Added during past 12 months.	Total up to 30th September 1887.	Up to 30th September 1886.	By Surveyor-General's Office during past 12 months.	Total to 30th September 1887.	Remaining to be published.	
North-West Provinces.								
Agra	2,942(a)	...	2,942	2,942	...	2,942	...	
Azamgarh	930	...	930	930	...	930	...	
Ballia	1,394	...	1,394	1,394	...	1,394	...	(a) Figures of previous return have been changed to agree with final results.
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	3,010	4,535	4,545(b)	199	1,291	1,490	3,055	
Benares	1,816(a)	..	1,816	1,810	6(c)	1,816	...	
Bijnor	31	...	31	31	...	31	...	
Dehra Dun	701	...	701(b)	651	...	651	50	
Ghazipur	3,050	...	3,050	3,050	...	3,050	...	
Gorakhpur	3,243	1,629	4,872(b)	1,123	1,231	2,354	2,518	(b) These figures are liable to alteration until publication has been completed.
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,434	...	3,434	3,434	...	3,434	...	
Moradabad and Tarai	4,023	...	4,023	4,023	...	4,023	...	
Muttra	1,658	...	1,658	1,658	...	1,658	...	
Mirzapur	3,645(a)	...	3,645	3,638	...	3,638	7	
Tarai	346	...	346	346	...	346	...	(c) Includes 5 sheets of Benares City survey on the 32-inch scale.
TOTAL	36,466	3,164	39,630	31,472	2,528	34,000	5,630	
Burma.								
Akyab	1,861	441	2,302(b)	647	662	1,309	993	
Bassein	3,076	...	3,076	3,076	...	3,076	...	
Hanthawaddy and Pegu	4,601	...	4,601	4,601	...	4,601	...	
Henzada	1,391	...	1,391	1,391	...	1,391	...	
Prome	847	...	847	847	...	847	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	...	
TOTAL	13,139	441	13,580	11,925	662	12,587	993	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	
Pooree (Khorda Estate)	4,565	...	4,565	4,565	...	4,565	...	
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Mozufferpore	...	1	1	...	1	1	...	
TOTAL	12,543	1	12,544	12,543	1	12,544	...	
Assam.								
Kamrup	1,675(a)	...	1,675(b)	1,023	652	1,675	...	
Sylhet	61	...	61	16	...	16	45	
TOTAL	1,736	...	1,736	1,039	652	1,691	45	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
TOTAL	43	...	43	43	...	43	...	
GRAND TOTAL	63,927	3,606	67,533	57,022	3,843	60,865	6,668	

Abstract of work performed during 1886-87.

PROVINCE.	NUMBER OF SHEETS.				REMARKS.
	Examined and rendered suitable for Photo-zincography.	Traced and examined for Zincography.	Proof copies examined previous to press orders.	Coloured and subsequently examined.	
North-West Provinces	1,863	817	2,583	2,528	Scale 16 inches=1 mile.
Burma	296	60	502	662	Ditto ditto.
Bengal	1		1	...	Ditto ditto.
Assam	401	234	652	...	Ditto ditto.
TOTAL	2,561	1,111	3,738	3,190	

ENGRAVING OFFICE, CALCUTTA.

Statement showing the work performed during the year 188 -87.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks.
	Sq. In.	Letters cut.	Sq. In.	
Indian Atlas.	...	...	...	Scale 1 inch = 4 miles.
Quarter Sheets (new) completed.				
6 S. E.	...	1,264	...	Produced in heliogravure, title, imprint, and outside lettering cut.
12 N. W.	18	3,380	61 H 8 marsh	Completed.
14 S. W.	...	1,166	...	Produced in heliogravure, outside lettering engraved.
15 S. W.	...	1,150	23 H.	
18 S. E.	...	455	19 S. H.	Completed to margin.
20 S. E.	...	698	10 H. 23 S.H.	
50 N. E.	7	13,189	7 H.	
Total	25	21,302	101H 42 S.H. 8 marsh.	
Quarter Sheets (new) in progress.				
11 N. W.	18	1,480	...	Scale and outside figures cut, outline in progress.
11 S. E.	50	98	...	Outline completed as far as material supplied, writing about to be put in hand.
11 S. W.	130	2,214	...	Ditto ditto.
12 N. E.	3	...		Slight additions to outline, completed.
14 N. E.	...	412	...	Outline and writing completed as far as material supplied.
14 S. E.	...	3,586	...	
15 N. W.	16	4,612	...	
16 N. W.	...	3,910	...	Writing in progress.
16 S. W.	...	8,056	...	
19 S. E.	...	102	15 H.	Well advanced, almost completed.
21 S. E.	...	110	...	Slight corrections completed.
21 S. W.	...	1,382	...	Outside figures and new scale cut.
22 N. E.	2	8,024	...	Reprojected, new border and scale cut, outline and writing completed as far as material supplied.
23 N. E.	36	2,290	...	Reprojected, new border and scale cut, outline and writing in progress.
23 S. E.	38	1,675	...	Water-lining, additional outline and writing completed, as far as material supplied, hills just commenced.
24 N. E.	5	...	...	Additional outline completed as far as material supplied.
27A S. W.	3	515	...	Border and outline completed as far as material supplied, writing in progress.
28 S. E.	...	5,169	...	Electrotyped from the full plate, border engraved, corrections in progress.
28 S. W.	12	4,9 7	26 H.	Electrotyped from the full plate, border, new scale, outside figures and additions completed, under examination.
35 S. W.	...	1,336	40 H.	In progress.
36 N. W.	2	44	...	Slight corrections to outline and writing, completed.
37 N. W.	1	9,860	...	Outline and writing completed as far as material supplied.
37 S. W.	...	3,091	...	Writing completed as far as material supplied.
38 N. E.	...	412	...	
38 N. W.	...	158	...	Slight corrections, completed.
39 N. E.	...	4,537	...	Writing in progress.
39 N. W.	...	50	152 H.	Hills well advanced, in progress.
39 S. E.	...	...	134 H.	
Carried over	318	68,080	367 H.	

ENGRAVING OFFICE, CALCUTTA.

Statement of work—continued.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks.
	Sq. In.	Letters cut.	Sq. In.	
Quarter Sheets (new) in progress—continued.				
Brought forward .	318	68,080	367 H.	
40 N. W.	...	260	...	Writing in progress.
42 S. E.	...	5,089	...	Writing completed as far as material supplied.
43 N. E.	...	4,083	...	
43 S. E.	...	66	...	Slight corrections, completed.
48 N. E.	...	13,698	...	Outline and writing completed to margin, waiting hill drawing.
48 N. W.	10	...	...	Border cut and outline completed, as far as material supplied.
48 S. W.	...	2,748	...	Outline and writing completed, as far as material supplied.
50 N. W.	172	...	...	Outline well advanced, in progress.
50 S. E.	150	11,384	8 S. H.	Well advanced, writing almost completed.
57 N. W.	110	...	...	Outline completed as far as material supplied.
57 S. W.	42	...	...	
59 N W.	126	1,882	...	Outline completed as far as material supplied, writing in progress.
59 S. E.	128	66	...	
59 S. W.	232	5,941	...	Outline completed to margin, writing in progress.
60 N. E.	27	19,467	...	
60 N. W.	...	10,963	...	Outline and writing completed to margin, numerous lakes shaded, hills just commenced.
60 S. E.	129	7,479	...	Outline completed to margin, writing well advanced, in progress.
60 S. W.	221	1,235	...	Outline completed as far as material supplied, border and outside figures cut, writing about to be put in hand.
61 N. E.	...	3,292	...	Outline and writing completed to margin, lakes shaded, waiting hill drawing.
61 N. W.	110	525	...	Outline completed as far as material supplied, outside figures cut, writing about to be put in hand.
68 N. W.	...	2,609	...	Writing in progress.
75 S. E.	...	1,875	...	
76 N. E.	...	125	...	Slight additions finished, waiting hill drawing.
76 S. W.	...	2,000	...	Additional writing cut, waiting hill drawing.
77 N. W.	...	...	...	Lakes shaded, outline and writing completed to margin, wating hill drawing.
78 N. E.	...	...	...	Reprojected, lakes shaded, completed as far as material supplied.
78 N. W.	79	...	...	Border cut, outline completed as far as material supplied, writing in progress.
78 S. W.	6	5,963	...	Outline completed as far as material supplied, writing in progress.
88 N. E.	...	6,589	...	Writing in progress.
88 S. E.	40	4,886	...	Outline completed as far as material supplied, outside figures cut, writing in progress.
103 N. W.	...	376	...	Outline completed as far as material supplied, outside figures cut, writing about to be put in hand.
103 S. W.	...	707	...	
114 S. E.	59	6,350	...	Outline completed as far as material supplied, writing in progress.
114 S. W.	4	4,670	...	Outline and writing completed to margin, hills about to be put in hand.
125 S. E.	...	12,295	...	Writing well advanced, in progress.
Total .	1,963	2,04,703	367 H. 8 S. H.	

ENGRAVING OFFICE, CALCUTTA.

Statement of work—continued.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks.
Additions and Corrections to Quarter Sheets.	Sq. In.	Letters cut.	Sq. In.	
8 N. E.	...	10	...	Slight corrections, completed.
9 S. E.	10	400	...	Electrotyped, sandhills being taken off the matrix plate.
12 S. W.	2	18	...	Slight additions and corrections, completed.
20 N. E.	...	10	...	Slight corrections, completed.
22 S. E.	...	876	...	Corrections and additions, completed.
32 S. E.	...	265	...	
32 S. W.	...	59	...	Corrections to district names, completed.
33 N. E.	...	275	...	
33 N. W.	...	10	...	
36 S. E.	...	237	...	
37 N. E.	...	237	...	
38 S. W.	...	400	...	Heavy corrections to spelling, heights, &c., being carried out on the matrix plates.
39 S. W.	...	500	...	
45 S. E.	...	38	...	Slight corrections, completed.
48 S. E.	...	354	...	
51 N. E.	...	270	...	Corrections to outline and writing, completed.
53 N. W.	...	165	...	
53 S. W.	...	367	...	
66 S. W.	...	42	...	
67 S. E.	2	150	...	
70 S. W.	14	562	...	
71 N. W.	...	617	...	
71 S. W.	...	476	...	
91 N. E.	...	575	...	Slight corrections, completed.
91 S. E.	...	50	...	Electrotyped, corrections to boundaries and district names.
91 S. W.	...	1,135	...	Corrections and additions to railways, boundaries and district names, completed.
92 N. E.	...	318	...	Corrections and additions to boundaries and district names, completed.
92 N. W.	3	423	2 H.	Heavy additions and corrections to boundaries and district names, completed.
92 S. E.	2	50	...	
93 N. E.	...	50	...	Corrections and additions to boundaries and district names, completed.
93 N. W.	...	308	...	
95 N. W.	...	122	...	
105 S. E.	...	10	...	Slight corrections, completed.
126 N. W.	...	360	...	Additional railway engraved.
127 N. E.	20	50	...	Corrections and additions to boundaries and roads.
127 S. E.	20	50	...	
Total	73	9,839	2 H.	
Additions and Corrections to full Sheets.				
25	...	...	78H	Hills repaired, completed.
28	...	531	...	Additions and corrections engraved.
40	...	...	22H	Hills being repaired.
46	...	9,250	...	Writing recut, both hills and writing completed, the plate having undergone thorough repair.
47	...	...	143H	Hills being repaired, plate well advanced, in progress.
50	16	119	...	Additions and corrections to roads, canals and railways, completed.
65	...	...	211H	Hills being repaired, in progress.
79	...	16	...	Slight additions, completed.
94	30	2,987	...	Heavy additions and corrections to boundaries, roads and district names, in progress.
121	41	1,637	...	Ditto ditto, completed.
Total	87	14,540	454H	
New Plates projected, Borders cut, &c.				
57 N. E.	...	...	...	New border being cut, in progress.
75 N. E.	...	...	...	Projected, border being engraved, in progress.
75 N. W.	...	...	...	
75 S. W.	...	...	...	Projected.

ENGRAVING OFFICE, CALCUTTA.

Statement of work—continued.

Title of Map.	Number of sheets and scale.	Outline, square inches.	Number of letters cut.	Hills(H) Sand (S), square inches.	Remarks.
General Maps.					
India	6 1 inch=32 miles.				
Sheet 1 . .	...	102	148	10H.	Corrections and additions both on original and duplicate plates, large portion stoned off, re-projected, outline cut, writing in progress.
„ 2 . .	...	1	36	10H.	Hills engraved on duplicate plate, with slight additions to outline and writing.
„ 3 . .	...	25	58	155H.	Additional outline engraved, hills well advanced, in progress.
„ 4 . .	...	10	1,792	5H.	Corrections to outline, writing and hills completed.
„ 5 . .	...	...	325	...	Corrections to boundaries, railways and names both on the original and duplicate plates, completed.
„ 6 . .	...	...	10	...	Slight corrections, completed.
India	2 1 inch=80 miles.	...	58	...	Slight corrections, completed.
India	1 1 inch=96 miles.	...	34	...	
India	1 1 inch=128 miles.	...	58	...	
India	1 1 inch=256 miles.	...	32	...	
Himalaya route map .	1 1 inch=32 miles.	...	34	...	Slight additions, completed.
Total .	.....	138	2,585	180H.	
Provincial Maps.					
Bengal	2 1 inch=16 miles.	...	1,236	201H.	Corrections to outline and writing, hills almost completed as far as material supplied, in progress.
Bengal	1 1 inch=64 miles.	...	36		
Rajputana . .	Ditto	2	149	5H,13S.	Additional outline, writing and hills completed.
Central Provinces .	Ditto	2	103	...	Corrections to outline, and writing in progress.
Punjab	4 1 inch=16 miles.	328	4,717	...	Outline completed, writing in progress.
Assam	1 1 inch=16 miles.	30	1,102	15H.	Additional outline, writing and hills completed.
Mysore	Ditto	129	688	...	Projected, border cut, outline well advanced, in progress.
Gujarat . . .	Ditto	...	...	...	Projected and awaiting material.
Orissa	Ditto	...	56	...	Slight additions, completed.
Oudh	Ditto	...	56	...	
Sind	Ditto	...	34	...	
Berar	1 1 inch=8 miles.	...	38	...	
Punjab	1 1 inch=32 miles.	37	1,600	...	Heavy corrections to outline and writing, completed.
Divisional Maps.					
Bhagalpur . . .	1 1 inch=16 miles.	...	36	...	Slight additions, completed.
Burdwan . . .	Ditto	...	36	...	
Chittagong . . .	Ditto	...	36	...	
Chota Nagpore . .	Ditto	...	34	...	
Carried forward .	.....	528	9,957	221H,13S.	

ENGRAVING OFFICE, CALCUTTA.

Statement of work—concluded.

Title of Map.	Number of sheets and scale.	Outline, square inches.	Number of letters cut.	Hills(H) Sand (S), square inches.	Remarks.
Divisional Maps—*contd.*					
Eastern Districts, Dacca	1 1 inch=16 miles.	...	36	...	
Western Districts, Dacca	Ditto	...	36	...	
Patna	Ditto	...	36	...	
Presidency	Ditto	...	36	...	
Rajshahi and Cooch Behar	Ditto	...	36	...	Slight additions, completed.
Plans of Cities and Cantonments.					
Simm's Plan of Calcutta	4 14 inches=1 mile.	...	36	...	
Simla and Jutog, plan of	4 3 inches=1 mile.	...	135	...	Corrections to outline and writing on two plates.
Administration Report Maps.					
Bengal	1 1 inch=80 miles.	3	837	...	Projected, border, outline and title engraved, writing about to be put in hand, being electrotyped, in various stages.
North-Western Provinces and Oudh	Ditto	23	959	...	
Charts.					
Index Great Trigonometrical Survey	...	...	450	...	Additions, completed.
Miscellaneous.					
The Viceroy's appointment plate	...	...	400	...	Slight alterations, completed.
Standard symbols for the Revenue Survey	...	...	2,775	...	Engraved.
Archæological Survey	...	...	874	...	Two plates in heliogravure, lettering cut for Photo. Office.
Map Headings	...	...	361	...	Two plates, additions completed.
Imprint plates	...	...	1,059	...	Three plates, new plate engraved, old ones corrected.
Vernier scales	...	...	606	...	Five scales figured for Mathematical Instrument Office.
Theodolite Circle	...	...	599	...	One circle figured for Mathematical Instrument Office.
Scale of Gunter's chains 8 inches=mile	...	...	326	...	Completed.
Heliogravure plates	...	...	804	...	Two titles cut for Photo. Office.
Total	...	604	20,349	221H. 13S.	

Abstract of Work.

Engraving.

	Plates.
Atlas sheets completed	7
Ditto in progress	63
General maps, plans, &c.	69
Repairs, corrections, and additions	46
Projections engraved, borders cut, &c.	4
Total	189

Copper-plate printing.

Impressions taken	10,967
Proofs pulled	470
Transfers pulled	284
Total	11,721

Steel-facing.

	Plates.
Double elephant plates steel-faced	19
Ditto ditto steel-removed	38
Quarter plates steel-faced	51
Ditto steel-removed	87
Miscellaneous plates steel-faced	17
Ditto ditto steel-removed	5
Total	217

Square inches of hill etching	1,388
Ditto of jungle etched	8
Ditto of outline	2,890
Number of letters engraved	273,318

PHOTOGRAPHIC OFFICE, CALCUTTA.

Extract from the Narrative Report of LIEUTENANT-COLONEL J. WATERHOUSE, *Assistant Surveyor General,—Season 1886-87.*

OUT-TURN.—Owing to a large decrease in the number of original subjects received for reproduction, the out-turn of work for the year is considerably below the average. In the Zinc-printing Section, the number of copies printed of ordinary departmental and extra-departmental maps and plans also shows a falling off as compared with the number of original sheets received. Of cadastral maps the average number of copies printed of each original sheet is slightly in excess of last year, though the total, both of original sheets and printed copies, is much less. The number of prints turned out by the helio-gravure and photo-collotype processes and of hand-engraved plates electrotyped is greater than in any previous year.

ORIGINAL SUBJECTS.—The total number of original maps and plans received for reproduction in the Normal Sections of the Office was 1,185, as against 1,518 in the preceding year. Of these, 719 were the regular departmental maps and 466 were received from other departments. In the Cadastral Sections, 3,618 original sheets were received, of which 2,502 were reproduced by photozincography and 1,116 zincographed from tracings.

NEGATIVE SECTION.—During the year, the number of negatives taken was 4,369, inclusive of reversed negatives and transparencies, of which 1,154 were of departmental maps, 713 extra-departmental maps and plans and 2,502 cadastral maps.

The processes employed in this section have for the most part remained unchanged throughout the year. The method of intensifying with bromide of copper and nitrate of silver was abandoned on account of the expense, but has lately been tried again with improvements which make it much cheaper in working and it is now being used very successfully in the Cadastral and Normal Sections and will be further reported on in due course next year.

Some experiments were made with the view of introducing a cheap substitute for the benzole crystal varnish with which all negatives that require to be kept for any length of time are coated. The varnish is prepared by dissolving shellac in a solution of borax and carbonate of soda. The formula was given in the *British Journal of Photography* for April 22nd 1887 and is as follows:—

Bleached lac (ordinary best pale shellac will answer)	32 parts.
Borax	8 „
Carbonate of soda	2 „
Glycerine	1 to 2 „
Water	320 „

The borax and carbonate of soda are dissolved in 160 parts of hot water and the lac, broken into small pieces, is added. The containing vessel is then placed over a clear fire and stirred until the lac is dissolved. The solution is allowed to cool partially and then filtered, after which the glycerine is added and the bulk made up to 320 parts. After a few days, a sediment separates out, and the solution should again be filtered till clear and bright. This varnish, though very suitable for gelatine negatives, for which it was originally recommended, was found scarcely strong enough for collodion ngatives, with the very tender films resulting from intensification with bichloride of mercury followed by hyposulphite of soda and ammonia. With the addition of more shellac it may perhaps be found suitable for the negatives intensified with bromide of copper and silver. It has the advantage of exceeding cheapness, costing only about 4 annas a litre, while the comparatively cheap crystal varnish costs R3-8 per litre and alcoholic varnishes are still more costly.

In July this section lost the services of Mr. J. Mackenzie, the Head Photographer, who was compelled by failing health to retire on an invalid pension after 25 years' service. During the whole of this period Mr. Mackenzie had been attached to the section, and the perfection to which the processes had been brought is in a great measure due to his industry and skill. On his retirement Mr. G. G. Dempster held charge of the section from the 16th July until the 12th August, when Mr. H. Haward returned from privilege leave and was placed in charge.

PHOTO-TRANSFER SECTION.—The number of photo-transfers printed was 4,299, of which 1,775 were departmental and extra-departmental maps and plans and 2,524 cadastral maps.

A new method of preparing the transfer paper with arrowroot was introduced during the year, which has the advantage of being very much cheaper than the method of coating with gelatine usually adopted, and of giving results quite as good, if not better.

Bank post paper is coated in the usual way with two coats of the following mixture:—

Arrowroot	140 parts.
Bichromate of potash	70 „
Water	3,500 „

In the cold weather the bichromate may be increased to 90 parts. After exposure to light the prints are coated with transfer ink in the press as usual, the transfer ink used being composed of—

Hard retransfer ink (plate to stone)	100 parts.
Litho-chalk ink	100 to 140 „
Palm oil	7 „

After inking in, the prints are washed off with hot water—hotter than is required for gelatine transfers, but in the cold weather it has been found better to use cold water for soaking and washing off, only finishing with hot to remove the soluble arrowroot. Under favourable conditions the arrowroot transfer prints go down well on the zinc and give almost clearer and sharper transfers than gelatine, but considerable trouble has been found in working the process from the difficulty of clearing the prints from soluble arrowroot which appears to spread over the lines while the prints are hung up to dry or during transfer and prevents the transfer ink from taking properly on the zinc. It may also be stated that whereas the arrowroot was found to give better transfers than gelatine in the hot weather and rains it has not done so in the cold weather. Efforts are being made to overcome these difficulties without having to revert to gelatine which is over 40 times more expensive.

Some experiments were made by Mr. Harrold with Sergeant-Major Husband's process known as "Papyrotint," briefly described in last year's report, by which grained transfers suitable for printing from stone or zinc are prepared from half-tone negatives. Mr. Harrold has succeeded in obtaining fairly good results from a modification of the process which may be described as follows:—

Thick bank post paper is floated for about a minute on a solution of—

Gelatine (opaque No. 2)	6 parts.
Common salt	1 „
Water	46 „
Glycerine	1 „

and hung up to dry in a temperature of about 100°F., and when dry, coated a second time. When again perfectly dry, the paper is sensitised in a bath of bichromate of potash consisting of—

Bichromate of potash	10 parts.
Common salt	5 „
Ferridcyanide of potash	2 „
Water	300 „

The paper is floated on the solution for one minute and dried by heat in the usual way when it is ready for printing. The length of exposure depends on the quality of the negative. A good clear negative requires about one minute in bright sunlight or six minutes in the shade. When printed, the paper is soaked in cold water for a few minutes, then dried between sheets of blotting-paper and rolled up with the ink ordinarily used for coating photo-transfers or with an ink of the following composition—

White virgin wax	1 part.
Stearine	1 „
Common resin	1 „
Chalk printing ink	8 parts.

This mixture should be reduced to the consistency of cream with spirits of turpentine and a small quantity spread on the print with a sponge. An India-rubber roller is then charged with the same ink, but of a slightly thicker consistency than that which is applied with the sponge, and the print is rolled up in the usual way. It can then be washed and put down on zinc or stone like an ordinary photo-transfer. If a coarse grain is required it can be easily obtained by using a thicker coat of gelatine on the paper.

The process has not yet come into regular use, but could be used in cases where collotype or heliogravure would be too slow or not otherwise applicable. For general purposes the method of transfer from heliogravure plates prepared with a coarse grain, as noticed under that section, appears likely to be more useful.

SILVER PRINTING SECTION.—There was not a very great demand for silver prints during the year. The number printed was 1,308, including 485 prints of Major Durand's Afghan Boundary Commission sketches, supplied to the Foreign Department; two complete sets of prints of Mr. C. L. Griesbach's negatives, made for the Director, Geological Survey, and 277 prints of Mysore Topographical Survey sheets supplied to the Mysore Government.

For ordinary office purposes, reductions of standard sheets, &c., silver printing has been almost entirely replaced by the cheaper cyanotype process, by which 128 prints were produced. This section was also employed in preparing albums of photographs of the Gilgit Mission, for the Viceroy and Foreign Office, and of the Exhibition photographs for the Revenue and Agricultural Department.

PHOTO-COLLOTYPE SECTION.—In this section 6,608 prints were made from 30 plates. The number of prints is much larger than last year, though fewer plates were prepared. The style of work turned out maintains its high quality and would compare favourably with that done in European establishments.

The work done by this process during the year includes several plates of inscriptions for the Archæological Survey; copies of coins and of a broken clay seal for the Asiatic Society, taken from the originals; and a plate of *Ficus Roxburghii*, for the Superintendent of the Royal Botanical Gardens, from a very dense paper negative taken from nature by Dr. D. D. Cunningham. Nearly all the subjects were of unusual difficulty and showed well the capabilities of the process.

Owing to the section being fairly well employed throughout the year, not much experimental work was done, but trials were made of Husnik's method of employing zinc

plates as a substitute for the thick glass plates used as support for the gelatine printing surface. The plates did not stand printing well and gave no advantage over the ordinary process.

HELIOGRAVURE SECTION.—The work done by Mr. A. W. Turner in this section shows a very satisfactory increase, and both processes, photo-electrotype and photo-etching, have been worked steadily and successfully throughout the year. The number of plates reproduced by photo-electrotype was 22, or 12 more than last year, and 23 plates were reproduced by the photo-etching process. The total number of prints was 292, chiefly copies of a plate of a very well executed drawing of the Central Bay of the Temple at Ittigi (Archæological Survey of Western India) for the Technical Art Series of the Government of India. In addition to these, however, 1,185 copies of three plates were printed in the copper-plate presses of the Engraving Office.

Photo-electrotype.—There has practically been no change in the working of the photo-electrotype process during the year. It has given very good results for fine line work, as in the case of the pen-and-ink drawings of the Archæological Survey of Western India, which have been reproduced in consultation with Sir Edward Buck and Dr. Burgess for a Technical Art Series, for the use of Art Schools and also for the illustration of Dr. Burgess' Archæological Survey Reports. Transfers of them are also to be sent to Mr. W. Griggs for the illustration of the *Indian Art Journal*. Four of these drawings have been reproduced during the year, besides two of the Madras Archæological Survey. A sheet of the Andaman survey on the ½-inch scale has also been reproduced by direct reduction of two standard sheets on the ½-inch scale. It is intended to reproduce all these sheets in this manner and avoid the expense of hand-engraving. A quarter sheet of the Atlas of India, No. 6 S.E., has also been reproduced in this manner from a pen-and-ink drawing specially prepared for the purpose. Another quarter Atlas sheet, No. 14 S.W., with brush-shaded hills, was also reproduced from the original drawing by this process, the gelatine relief being treated with waxed emery powder, as described in the Annual Report of this office for 1881-82. This method is much more suitable than the photo-etching process for reproducing originals of this kind where brush-shading is combined with outline. The drawing in question had been rubbed with India-rubber and reproduced rather coarsely, but in other respects the reproduction was successful. Further experiments were tried with the method referred to in last year's Annual Report for obtaining half-tone transfers to zinc or stone by using a coarse sand grain and making a thin electrotype merely for transfers. The results were good and the process seems likely to be of service for the cheap reproduction of photographs in half-tone.

A new autogravure tissue, prepared by the Autotype Company, which I brought out from London, was tried in the early part of the year. The gelatine coating of this tissue contains a quantity of plumbago and black oxide of manganese with the object of giving a relief image with a sharp grain that will electrotype well without the further application of plumbago and not require any granulation with waxed sand or emery. It was not found, however, to work very well, the great opacity of the manganese preventing the light from penetrating sufficiently deep to obtain the required relief, and consequently the prints, whether in line or half-tone, were dull and flat.

Photo-etching.—Mr. Turner devoted most of his attention during the year to the photo-etching process and has made considerable improvements by following the method of etching the plates with a succession of baths of perchloride of iron solution of gradually diminishing strength, which I saw in use at the Military Geographical Institute at Vienna in 1886. The plates prepared by the process as originally tried here were found to stand very little printing, it being seldom possible to pull a sufficient number of proofs before steel-facing without seriously injuring the finer details. Moreover, in line subjects there was always a slight want of sharpness.

In the Vienna process the early stages of the operations are almost exactly the same as in the method we had worked out here (see Annual Reports for 1883-84 and 1884-85) with the exception that the dust-grain on the copper-plate is fixed by heat instead of by fuming with benzole or oil of lavender. Mr. Turner has, however, adopted the fixing by heat with advantage. The main difference is in the etching. We used only one bath, but in Vienna four are used, prepared by dissolving 68, 67, 66 and 65 parts of perchloride of iron respectively in 50 parts of water. These solutions are kept in bottles numbered 68, 67, 66, and 65.

The solutions are poured into four porcelain trays side by side, and the plate, having its back and the blank margins of the picture protected with black varnish, is immersed in the first or strongest solution for about five minutes, so as to etch the deepest shadows in the parts where there is little or no gelatine, and then transferred in succession to Nos. 2, 3, and 4 solutions, being kept for about five minutes in each, the progress of the etching being carefully watched meanwhile. After passing through the last bath the plate is plunged into cold water and washed till free from perchloride of iron.

The gelatine film having been removed by gently rubbing with a muslin or cotton rag, the plate is dried and washed with benzine to remove the resinous grain and varnish from the face. It is then turned over carefully and laid face downward on a sheet of clean paper and the varnish removed from the back. The face of the plate is next carefully rubbed over with fine whiting and ammonia, dried and polished off with a little spirit.

This method of cleaning the plate after etching has been found by Mr. Turner to be very useful.

The above solutions of perchloride of iron are considerably stronger than the etching solutions hitherto used in the office, and consequently they admit of the gelatine film being much thinner, which gives a much sharper image in biting. Mr. Turner has found that even stronger solutions can be used with advantage, and he is now using solutions at 45°, 40°, 36°, and 27° Baumé, as recommended by Professor W. Roese for the photo-typographic etching process noticed below. The specific gravities of the solutions, at the temperature of 63·5° F., are 1,4421, 1,3746, 1,3250 and 1,2254 respectively, the percentage of anhydrous perchloride being about 47, 41, 37, and 27. A solution made up to 48° B. was tried, but at this strength the thinnest possible film of gelatine formed a resist which the perchloride could not penetrate, even after prolonged soaking. The slight scum of gelatine which is almost always present, especially in the hot weather, formed as perfect a protection to the copper as a strong solution of asphalt. For ordinary subjects, therefore, a solution of this strength is practically too strong, but it might be found very useful for etching pure line subjects in relief if an image could be obtained absolutely free from any trace of gelatine in the parts required to be eaten away. With fresh tissue in the cold weather it might perhaps be done. For line subjects solutions of 45° and 40° B. need only be used, if the image is thin, and this gives a very sharp clean etching. For half-tone subjects, the strongest perchloride (45°) should not be left on for more than one minute after it first attacks the copper; the 40° solution may remain on 3 or 4 minutes; the 36° solution about 2 minutes, and the 27° may remain until it just reaches the highest lights, not, as a rule, more than one minute. The use, however, of the varying strengths of perchloride is a matter purely of practice. Almost any effect can be obtained by varying the length of time the plate is exposed to solutions of different strengths. Temperature must also form a very important factor in the working of the process. Another point experimented upon by Mr. Turner is the quantity of powdered asphalt requisite to give the plate the necessary grain, and he has found that provided the powder is very fine a much larger quantity can be used than he had previously used, with the effect of making the plate much stronger and obviating the danger of the finer tints wearing away before steel facing.

Too coarse a grain gives a woolly image and too small a quantity of it may give a plate from which a few good proofs can be taken, but which will not stand the wear and tear of printing for any length of time.

Plates etched by this process require no touching up beyond a little oil-rubbing, which can easily be done without the assistance of a skilled engraver. They require careful, though not necessarily slow, printing. In fact, it is probable that more impressions could be got off in a day from one of these plates than from a hand-engraved plate when once the correct method of handling them has been acquired. Difficulty is still found in obtaining good results by the photo-etching process from a subject combining line and half-tone work together, such as brush-shaded maps with names and topographical details in outline, but Mr. Turner hopes to be able to overcome this in time.

The plates produced by the photo-etching process during the year include two very delicate drawings in pen and ink for the Scientific Memoirs, Indian Medical Department; two district maps, with hills, Hazára and Simla; two plates of a cocoanut grove, reproduced from the original negatives for the Government of Madras, and a medallion portrait of Her Majesty the Queen-Empress.

Photo-typographic etching.—Mr. Turner has also made further trials of photo-typographic etching processes, principally of a new method described in the *Jahrbuch für Photographie und Reproductions Technik*, for 1887, as practised by Professor Roese at the State Printing Office at Berlin, which gives exceedingly fine results.

The process is almost exactly the same as for *intaglio* photo-etching, the only difference being that a gelatine *positive* image is transferred from autotype pigment tissue, No. 103, on to the copper plate grained in the usual manner with asphaltum powder, the graining being repeated twice or three times if necessary. Instead of copper, brass plates may be used with the advantage of being cheaper. They are easily obtained of uniform texture and in this respect and in their resistance to wear are better than zinc, which is not suitable for this method. The perchloride of iron solutions for biting are of four or five different strengths—45°, 40°, 36°, 30° and 27°B. Distilled water should be used, but a little alcohol may also be added. The etching is performed in the same way as for the *intaglio* process, the plates remaining in each bath for a longer or shorter time as necessary, but as a rule about two to three minutes in each. During the etching the original should be referred to as a guide for comparison. For type-printing the depth of etching which would be sufficient for *intaglio* plates is not enough. The plate must therefore be rebitten until the proper depth is obtained. The rebiting is also done with perchloride of iron; the plate being carefully rolled in with wax-ink composed of—

Good printing ink	2 parts.
Bees' wax	1 „
Crude resin	1 „
(melted together)	

Of this ink, 100 parts are melted with 20 parts of turpentine and some asphalt.

Some of this composition is spread on a stone and the plate is carefully rolled in with it by means of a glue or leather roller or with a metal roller made of zinc, by which he finest parts remain open, and attention should be given that only the extreme surface

should be touched with the ink, leaving the depths free for the etching to work upon. The plate is then etched with perchloride, the operation being repeated as often as necessary to reproduce the required depth. Subsequent retouches can be made with the burnisher for strengthening shadows and with the roulette for bringing up lights or the converse of the *intaglio* process. The rolling up requires great skill and intelligence. The printing also is difficult, especially for printers who have no experience of such blocks.

The results produced by this method at the State Printing Office, Berlin, and also at the Military Geographical Institute in Vienna, where a similar method is worked, far surpass those produced by any other process of photo-typography, and I should be glad if we could successfully work it here. The trials made with it were most promising, but it will require further working out, and it is to be feared that it will be difficult to find printers here capable of dealing with these delicate blocks.

Electrotyping.—There has been a considerable increase in the amount of electrotyping done during the year, and 21 matrices and duplicates have been prepared, in addition to the photo-electrotyped plates, and include 5 double-elephant plates of 3 sheets of the 32-mile map of India; 8 plates of 6 quarter-sheets of the Atlas of India and matrix and duplicate of a small Provincial Map of Bengal. In the cold weather some difficulty was found in working the tray batteries in consequence of the sulphate of copper crystallising out at night, but by testing the solutions occasionally with the hydrometer and by taking out the boxes of sulphate of copper crystals at night, the solution was kept at a proper point of saturation, (about 29° B.,) to prevent the formation of crystals in the depositing trough.

ZINC PRINTING SECTION.—The number of plates printed off by the Normal establishment during the year was 774, the number of pulls being 129,556 and of copies 161,781. During the early part of the year there was considerable activity in the Normal branch of the section, all the presses being constantly employed, but towards the close of the cold weather there was a large decrease in the number of requisitions received, both for departmental and extra-departmental work. The latter half of the year was one of unusual slackness and some difficulty was experienced in keeping the zinc printing establishment supplied with work. A similar scarcity of work prevailed also in the Cadastral branch throughout the year. The total number of plates printed in this branch was only 3,744, the number of pulls being 116,081 and of copies 108,832. It should be remembered, however, that the out-turn of work in both branches of the section during the preceding year was abnormally large, the actual printing work done being much in excess of that done during any previous year.

ORTHOCHROMATIC PHOTOGRAPHY.—During the year I have devoted a good deal of attention to the methods of orthochromatic photography by which coloured maps, drawings, paintings and other coloured objects can be reproduced with much more correct effect of light and shade than can be done by the ordinary processes; tints containing more or less yellow or orange, which even in very pale shades reproduce black in an ordinary photograph, appear light when the orthochromatic plates are used, while tints of blue which reproduce as white, even in apparently deep shadows of the drawing, are reproduced with their proper value as shadows.

In 1873, Dr. H. W. Vogel of Berlin published his discovery of the fact that bromide of silver plates stained with certain dyes became more sensitive than similar plates unstained for the region of the spectrum absorbed by a solution of the dye used for staining the films, and that by this means the sensitiveness of such plates to the yellow and red rays could be enormously enhanced; and he showed that by placing a yellow transparent screen in front of the lens a band of yellow paper on a blue background could be photographed as white on a dark ground instead of black on a white ground; or the exact converse of the usual order of things.

Early in 1875, I made some experiments in this direction in connection with the preparations for photographing the spectrum of the corona at the total solar eclipse of April 5th by the party at the Nicobar Islands, of which I was in charge. Having met Dr. Vogel on that occasion, I was led to continue the experiments, partly on scientific grounds, but more particularly with the more practical object, for our purposes, of reproducing coloured maps and drawings. During the course of this work I found that one of the dyes I was trying, a very fluorescent pink dye called eosin, at that time only quite recently discovered by Baeyer and Caro, possessed the power of enhancing the sensitiveness of collodio-bromide or bromo-iodide of silver plates used either wet or dry, to the yellow and green rays of the spectrum to a far greater extent than any other dye previously tried by Dr. Vogel or myself, except cyanin, which, however, is not so suitable for general work. Having omitted to use the yellow screen, I did not, however, find the addition of the dye of much advantage for copying coloured drawings and shortly afterwards had to give up the experiments for more practically important work in the office.

In 1882 Messrs. Taillefer and Clayton, of Paris, took out a patent for preparing isochromatic dry gelatine plates containing eosin in combination with ammonia, the latter addition being one of the special points of their patent. These plates practically solved the problem of obtaining dry plates with great sensitiveness to the yellow rays, suitable for copying coloured paintings and drawings. Since then Dr. Eder and other experimenters have investigated the subject very fully, and it seemed desirable to try these methods, so as to have the means of reproducing coloured maps or drawings when required, which, however, is not often the case.

My first trials were with some of the French isochromatic plates, which M. Taillefer was kind enough to give me for trial when I was on furlough in 1886. Some of the smaller ones gave very good results for the reproduction of water-colour drawings, and I was also able with them to obtain some very successful photographs of the fireworks and illuminations on the occasion of the celebration of Her Majesty's Jubilee in February. Their exceeding sensitiveness for yellow light may be judged from the fact that lights from oil lamps at the distance of two miles were reproduced distinctly with an exposure of only five minutes, and several of the photographs of fireworks, with practically instantaneous exposures, showed distinctly the paths of rockets, &c.

The larger plates of the same manufacture were not so successful, and as it is always doubtful whether these imported stained plates will keep well, especially in such a trying climate. To ensure success the plates must be prepared here, I therefore tried the formulæ, Dr. Eder, of Vienna, and other friends were kind enough to give me when last in Europe, by which ordinary dry plates can be rendered colour-sensitive when required by bathing them in an ammoniacal solution of erythrosin, an alkaline salt of tetraiodfluorescin which is of a bluer shade than the ordinary eosins which are salts of tetrabromfluorescin.

After many trials the following formulæ were found to give the best results.

(i) Process without silver—

Bathe the dry plates for about one or two minutes in a solution of erythrosin containing about 1 part of the dye in 10,000 parts of water with 1 to 2 per cent. of ammonia added. A preliminary bath of weak ammonia at about 1 per cent. is recommended, but I have not found it necessary.

(ii) Process with silver—

This is a modification of the formula recommended by Messrs. Mallmann and Scolik, in the *Photographische Correspondenz* for 1886, No. 315. It gives exceedingly sensitive plates with fairly good keeping properties and appears in some respects preferable to the method without silver, though the latter gives very good results and is much less troublesome. 50 c.c. of an erythrosin solution, 1 : 1000 in water, are heated in a water bath by candle-light or in the dark room, and nitrate of silver solution is dropped in as long as a precipitate falls. The precipitate is allowed to settle, the supernatant liquid decanted off, fresh distilled water added, and the precipitate thrown on a filter and washed with distilled water until the washings show no milkiness with hydrochloric acid. When this point is nearly reached, the dye will begin to dissolve and with some samples the precipitate is very soluble; it is important, therefore, to use samples of erythrosin, or, preferably, the pure tetraiodfluorescin, which give an almost insoluble precipitate with nitrate of silver. (My best samples of these dyes have been obtained from Dr. T. Schuchardt, of Görlitz.) When all free silver has been removed, the precipitate is washed in the filter with 2 to 4 c.c. of strong ammonia mixed with 20 c.c. water. This generally dissolves the precipitate entirely and easily, but should it not do so, the ammonia solution can be passed through over and over again till all the dye is dissolved. Water may then be passed through the filter to make up 200 or 300 c.c., forming a bath in which the plates are bathed for one minute. Using the medium quantity of ammonia and water, the stained plates show a strong bluish pink colour when dry and retain a good deal of colour through developing and fixing till all the hyposulphite is washed out, when the dye also disappears.

Dry plates thus prepared seem to differ a good deal in their keeping properties. Some have kept well for over two months in the rains in a dark slide. Others, on the contrary, have shown fog round the edges in a few days. Keeping in ordinary grooved wooden or metal boxes is not to be recommended.

The plates must be prepared and developed in a very weak red or orange light and kept in the dark as much as possible.

For developing Marion's Britannia developer generally answers well and in many cases may be reduced to half-strength.

For work in this country dry plates should, if possible, be selected which will stand developing and washing without ice. Wratten and Wainwright's appear to be on the whole the most satisfactory, and for copying purposes the "ordinary" are better than the "instantaneous." Swan's plates are also very good, but are too soft for use in the hot weather.

In order to obtain the maximum of orthochromatic effect in copying coloured subjects with much blue or yellow in them, it is necessary to use a yellow screen to cut off the blue rays. The simplest and best way of doing this is to place a piece of thin structureless collodion (a collodion made with equal parts acetate of amyl and alcohol, with 1 to 2 per cent. of pyroxyline, has given me good results) stained yellow with a suitable yellow dye, such as chrysoidin, aurantia or uranin, in a double diaphragm made of thin sheet brass and used in place of the ordinary diaphragm of the lens. When using the yellow diaphragm the exposure must be increased about three times.

I have found that the same effect may be produced with greater advantage by throwing a beam of yellow light on to the picture while being copied. When sunshine is available an ordinary mirror covered with a film of gelatine, coloured with a suitable yellow dye, as above, may be used. The exposure is not longer than ordinarily required and the result is more harmonious than when the yellow diaphragm is used, the reds being

ORDINARY PLATE.

Bright yellow pagri.

Green pagri with orange pattern.

Dark grey cape and crimson vest.

Skirt, orange, with red chequers.

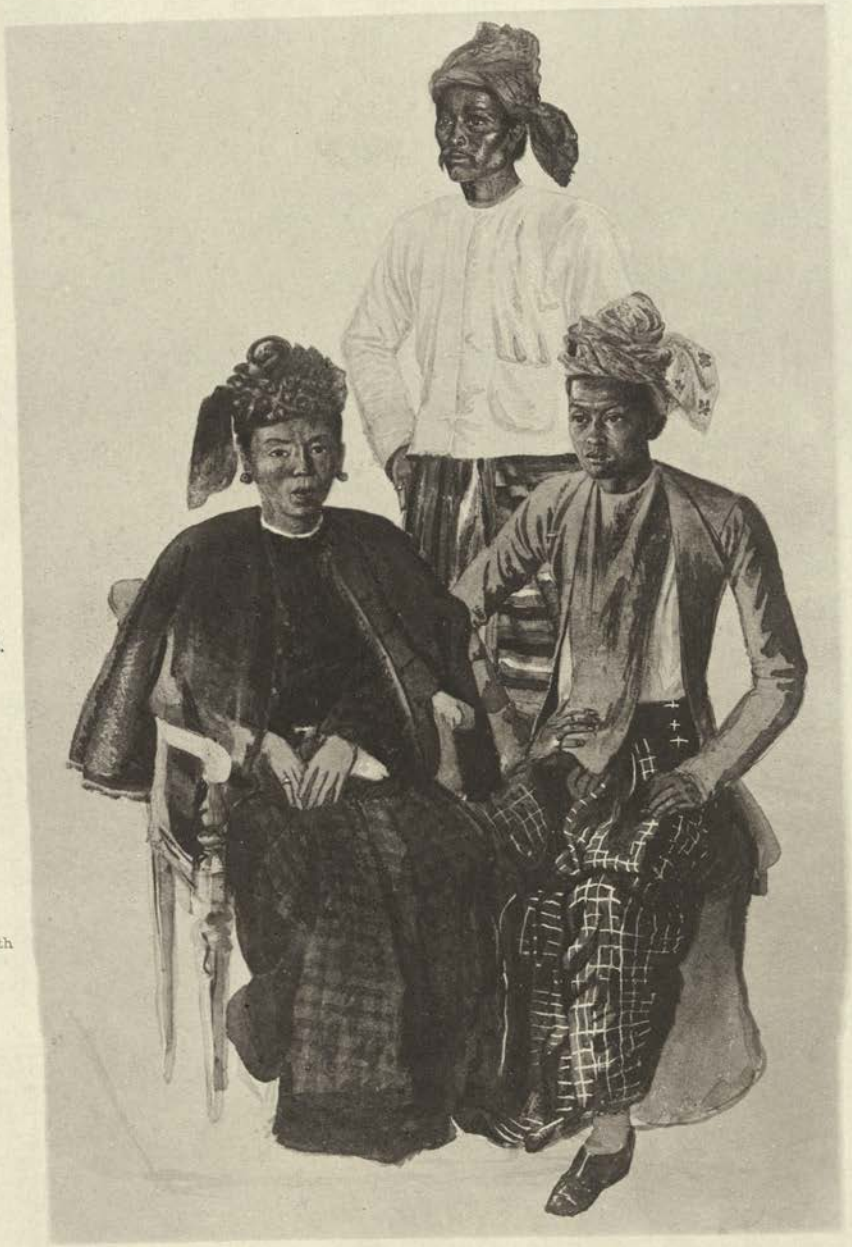

Photo-Collotype.

GROUP OF BURMANS.

Reproduced on an ordinary gelatine dry plate, unstained, from the original water-colour drawing by Colonel R. G. Woodthorpe, R.E., C.B.

Exposure 15 seconds.

ORTHOCHROMATIC PLATE.

Pink pagri with bright yellow flowers.

Blue coat.

Buff jersey.

Bright lemon yellow skirt with white lines.

Survey of India Offices, Calcutta, March 1888

GROUP OF BURMANS.

Reproduced on an ordinary gelatine dry plate stained with erythrosin-silver. Yellow light thrown on from a looking-glass covered with a film of gelatine coloured with chrysoidin. Exposure 12 seconds.

particularly improved. The method has the further advantage that the focus and sharpness of the image is not interfered with, as it is when yellow screens are applied to the lens, though when thin collodion screens are used in place of the diaphragm, this is exceedingly slight.

So far as at present known erythrosin is the most suitable dye for producing orthochromatic effect with gelatine dry plates, in the reproduction of yellow, but it has the defect of not increasing the sensitiveness for red. To improve it in this respect the addition of cyanin has been recommended, but then the general sensitiveness of the plate is greatly reduced. With plates so prepared and with plates prepared with a mixture of erythrosin and resorcin blue, the sensitiveness for red was slightly increased.

Dr. Vogel has recommended a mixture of chinoline red with cyanin (chinoline blue), known as azalin. This also works well, but has the same defect of want of general sensitiveness as the mixture of erythrosin and cyanin.

I have also tried the effect of dyes which have been found by Dr. Eder, to yield plates specially sensitive to the red rays of the spectrum, such as napthol blue, neutral violet, cœrulein, malachite green, iodine green, also gallocyanin (which I have found to have a strong sensitising effect for the red end of the spectrum, almost as much so as cœrulein) resorcin blue, Coupier's blue and azo blue, but none of these by themselves have given any useful result for copying purposes. The green dyes seem to make the plates indifferent to colour and the yellow screen has no effect. The blue dyes, as a rule, lower the general sensitiveness of the plates without much exalting the colour sensitiveness for yellow or red, and with some it is difficult to get clean-working plates.

In my earlier experiments, in 1876, with dry collodion plates, it was found that annatto, either in the emulsion or employed as a preservative, gave very great sensitiveness to all parts of the spectrum, as well as very sensitive plates for ordinary purposes. I have tried it again with gelatine and find a certain amount of improvement in colour sensitiveness, but not nearly so marked as with collodion. This dye requires further investigation.

Among red dyes, I have tried congo red, which gives a certain amount of sensitiveness for yellow, but not nearly so much as the eosins; roseine, which with collodion shows marked sensitiveness for yellow, does not do so with gelatine, and roshydrazin, which with the spectrum shows an increase of sensitiveness for yellow, but for copying shows only a very slight orthochromatic effect, being most sensitive, even with the yellow screen, for violet and blue.

Just before the close of the year some interesting results were obtained by photographing the spectrum on unstained plates with coloured screens in front of the slit of the spectroscope. Yellow screens give a particularly well marked increase of sensitiveness for the yellow and red rays. I found that this action had also been noted by Drs. Eder and Draper. A photograph of a petroleum lamp spectrum through a solution of tetraiodfluorescin on an unstained plate also produced a very marked increase of sensitiveness in the yellow, corresponding to the rise of sensitiveness of plates stained with the dye. Violet and green screens showed, in like manner, bands of increased sensitiveness in the red. Some trials were also made in copying coloured drawings, &c., on unstained plates through coloured screens, but further experiment is necessary to ascertain definitely what can be done in this direction.

I have found in the course of this enquiry that very different results are obtained from plates of different make. The causes of these differences have not yet been ascertained.

Altogether between 300 and 400 stained plates have been taken on the spectrum and in copying chromolithographs, water colour drawings and colour scales, with few exceptions, quite independently of my office work. I hope to continue these researches and report further progress. For present practical purposes the method of staining the plates with erythrosin-silver and throwing yellow light on the picture during exposure will answer. A photocollotype copy of a very highly coloured water-colour drawing by Colonel Woodthorpe, C.B., reproduced by this method, is attached, with a copy done on an ordinary plate. The difference between the two methods will be seen from a comparison of the bright yellow turban of the standing figure, and the skirts of the seated figures—in one case bright yellow with white stripes and in the other orange and red—in the two photographs. In the orthochromatic plate they are light and full of detail, and in the ordinary plate dark all over.

SOLAR PHOTOGRAPHS.—From time to time during the year, as opportunity offered, I have resumed experiments made in former years with collodion plates, in taking photographs of the sun in the eclipse camera on dry gelatine plates deeply stained with roseine and violet dyes, in the hope of being able to secure traces of the corona, as done in other ways by Dr. Huggins in England and by Mr. Gill at the Cape of Good Hope. This appears to be only possible when the sky is perfectly clear and free from haze, and such days have been very few during the past year. On the 8th May I got some photographs which when enlarged about three times show faint traces of detail round the sun which might be coronal. In some subsequent photographs something similar appears, but too faintly for comparison. There is always such a strong chance of error from defects in the optical arrangements, that the results must in any case be doubtful, unless they can be compared with photographs of the corona taken during an eclipse. I had hoped to have obtained some photographs that could have been compared with photographs of the corona taken during the total solar eclipse of August 19th, but the weather here about that time was very unfavourable for such work and even few successful photographs of the eclipse seem to have been

taken. With better arrangements and further experience in the working of stained plates and coloured screens it may, perhaps, be possible to obtain something more definite.

I have prepared a short treatise on the preparation of drawings for reproduction by photography, in which I have gathered together all available information on the subject of black and white drawings in pen and ink or shaded in monochrome and hope to be able, with the permission of Government, to publish it for departmental and general use.

NEW BUILDING.—Little progress was made in providing accommodation for these offices during the year, but on the question of fittings for the new offices arising, it was, in consultation with the Superintendent of Works, considered desirable to alter the proposed arrangements entirely, retaining the same accommodation generally, but placing the Photographic Office to the south and the Lithographic Office to the north in a quadrangle, the glass-house being placed on the upper storey at the back of the quadrangle. This arrangement will be very much better and more convenient. New rough plans had consequently to be prepared and the preparation of the list of fittings required postponed until the new plans were properly drawn out. At the close of the year they were not completed.

From the above it will be seen that although the general out-turn of the office has been comparatively small, the year has not been an inactive one, and considerable progress has been made in various directions.

PHOTOGRAPHIC OFFICE, CALCUTTA.

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map.		Sheets or Subjects.	Negatives.		Photozincographic Printing.				
		Original.	Reproduced.		Direct Negatives.	Reversed Negatives and Transparencies.	Photo.-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.
		M. I.	M. I.								
General Maps.											
Contour Map of India		...	...	...	6	...	...	...	4	400	200
Countries on either side of the North-West Frontier of India		...	...	...	...	...	...	...	1	100	100
Railway Map of India		...	...	...	...	...	...	...	24	1,218	1,218
Total		...	...	...	6	...	...	...	29	1,718	1,518
Provincial Maps.											
Central Provinces		16=1	32=1	...	...	...	...	...	1	150	150
Divisional Maps.											
Presidency Division and Sundarbuns		4=1	8=1	4	4	...	4	1	1	50	50
District Maps.											
(*North-Western Provinces*), Gharipur; (*Punjab*) Amritsar, Bannu, Delhi, Dera-Ghazi-Khan, Gurgaon, Jhang, Jhelum, Jullundur, Karnal, Lahore, Montgomery, Peshawar, Rawalpindi and Shahpur.		4=1	4=1	15	52	...	52	16	...	...	...
(*Assam*) Garo Hills		4=1	2=1	1	1	...	1	1	...	...	...
Khasi and Jaintia Hills and Lakhimpur		4=1	8=1	2	2	...	2	1	...	...	...
(*Bengal*) Hill Tipperah, Manbhoom, and Tipperah; (*Bombay*) Bassein; (*Central Provinces*) Chanda, Jubbolpore, Sambalpur, Saugor, Upper Godavari, and Wardha; (*Hyderabad*) Akola, Amraoti, Ellichpur, and Wun; (*North-Western Provinces*) Agra, Basti, Fatehpur, Fyzabad, Ghazipur, Gorakhpur and Moradabad; (*Oudh*) Hardoi, Kheri, and Sitapur; (Punjab) Rawalpindi; (*Rajputana*) Ajmere and Merwara,		8=1	8=1	28	25	...	25	11	...	...	...
(*Assam*) Sylhet; (*Bengal*) Balasore, Beerbhoom, Bogra, Bonai, Dacca, Durbhunga, Furreedpore, Garjat States, Gya, Hooghly, Howrah, Jessore, Konai, Lohardugga, Mayurbhanja, Monghyr, Moorshedabad, Mozufferpore, Mymensingh, Noakholly, Orissa, Pubna, Raishahye, Sarguja; Sundarbuns and 24-Pergunnahs; (*Bombay*) Bakar; (*Central Provinces*) Chhinduara; (*North-Western Provinces*) Ballia, Banda, Bareilly, Basti, Benares, Etah, Etawah, Jalaun, Muttra, Saharanpur and Shahjahanpur; (*Punjab*), Jhelum, Kohat, Montgomery and Muzaffargarh; (*Rajputana*) Chang.		8=1	8=1	47	35	...	35	9	8	2,250	7,200
(*Bengal*) Burdwan, Cuttack, Dinagepore and Pooree; (*North-Western Provinces*) Garhwal.		6=1	8=1	5	5	...	5	2	2	200	500
(*Bengal*) Cooch-Behar, Darjeeling, Hazaribagh, Jalpaiguri, Jashpur, Khoolna, Lohardugga, Maldah, Midnapore, Nuddea, Patna, Sarun, Shahabad, Singhbhoom, and Sonthal Pergunnahs; (*Central Provinces*) Balaghat, Betul, Bhandara, Bilaspur, Damoh, Hoshangabad, Nagpur, Narsinghpur, Nimar, Raipur and Seoni; (*North-Western Provinces*) Bijnor, Budaun, Bulandshahr, Hamirpur, Meerut, Mirzapur, Pilibhit and Tarai; (*Oudh*) Bahraich, Gonda, Lucknow, and Rae-Bareli; (*Punjab*) Banru, Hazara, Hissar and Shahpur;	...	...	...	...	...	...	...	...	15	4,350	8,750
(*Bengal*) Burdwan, Chittagong Hill Tracts, Cuttack, Dinagepore, Furreedpore, Howrah, Korai, Maldah, Mayurbhanja, Midnapore, Monghyr, Mozufferpore, Pubna, Pooree, Raishahye, Sarguja, Shahabad, Singhbhoom, and Sonthal Pergunnahs; (*Central Provinces*) Balaghat, Betul, Bhandara, Chhindwara, Damoh, Nagpur, Narsinghpur, Nimar and Raipur; (*North-Western Provinces*) Banda, Benares, Bijnor, Garhwal, Jalaun, Pilibhit, Saharanpur, and Tarai; (*Oudh*) Gonda and Rae-Bareli; (*Punjab*) Hazara and Shahpur.	...	...	...	...	...	...	...	...	14	700	2,100

OFFICE, CALCUTTA.

during the year 1886-1887.

Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.		Value.	Remarks.
Silver prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	115 5 7	Reprint.
...	...	...	...	...	...	...	...	...	...	46 11 8	
...	...	...	...	...	...	...	...	...	...	434 12 5	Reprint.
...	...	...	...	...	...	...	...	...	...	596 13 8	
...	...	...	...	...	...	...	...	...	...	19 3 3	
...	...	...	...	...	...	...	...	...	...	68 3 2	
...	...	...	...	...	...	...	...	...	...	697 2 11	
...	...	...	...	...	...	...	...	...	...	13 3 3	
...	...	...	...	...	...	...	...	...	...	27 14 5	
...	...	...	...	...	...	...	...	...	...	318 9 10	
...	...	...	...	...	...	...	...	...	...	659 11 6	
...	...	...	...	...	...	...	...	...	...	83 11 11	
...	...	...	...	...	...	...	...	...	...	423 3 11	
...	...	...	...	...	...	...	...	...	...	57 9 7	Reprint.

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map.		Sheets or Subjects.	Negatives.		Protozincographic Printing.				
		Original.	Reproduced.		Direct Negatives.	Reversed Negatives and Transparencies.	Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.
District Maps—*contd.*		M. I.	M. I.								
(*Bengal*) Bhagalpur, Orissa Tributary Mahals, Sundarbuns and Tipperah; (*Central Provinces*) Mandla; (*North-Western Provinces*) Agra, Dehra Dun, Etah, Etawah, Gorakhpur, Moradabad, Muttra and Muzaffarnagar; (*Oudh*) Sultanpur; (*Punjab*) Rawalpindi		...	8—1	...	...	...	...	...	4	1,300	2,900
(*Punjab*) Hazara and Simla		16—1	18—1	2	2	2	...	...	...	...	...
Total		...	...	100	122	2	120	40	43	8,800	21,450
Plans of Cities and Cantonments.		" ft.	" ft.								
Baroda City and Environs		1=200	1=200	...	...	...	...	...	16	2,400	2,400
Dalhousie Sanitarium		M. I. 1=10	M. I. 1=6	...	...	...	...	...	1	50	50
Dungarpur Environs and Kherwara Cantonment		{1=6	1=6	...	...	...	...	...	3	450	450
Moulmein Cantonment		{1=12	1=12	1	2	...	2	1	1	75	75
Rangoon Town District		1=16	1=12	...	...	...	...	..	20	1,000	1,000
Simla, Sheets 1 to 4, 6 to 8, 12 and 13		...	...	...	...	...	...	..	9	900	900
Total		...	1=24	1	2	...	2	1	50	4,875	4,875
Standard Maps.											
Andaman Islands.											
Sheets 1, 5, 6, 7, (3 and 11) 9, 10 and 16		{2=1 {1=4	2=1 1=4)	10	40	...	40	10	10	1,250	1,250
Assam.											
District Cachar— Sheets 57, 68, 69, 70, 80, and 81		1=1	1=1	...	...	...	...	...	...	600	600
Baluchistan.											
Sheets 1, 2, 21 $\frac{S.E.}{4}$ and 22 $\frac{S.E.}{2}$		{2=1 {1=2	2=1 1=2)	4	16	...	16	4	4	600	600
Bombay.											
Sheets 170 and 171		1=2	1=1	8	8	...	8	2	2	300	300
" 134, 172, and 204		1=2	1=1	12	12	...	12	3	...	...	...
" 133 and 239		...	...	...	...	...	...	...	2	300	300
Kolaba, Ratnagiri, Habsan and Bhor State— Sheets 141, 167 and 169		1=2	1=1	12	12	...	12	3	3	450	450
Districts Satara and Sholapur— Sheets 238 and 270											
Districts Ratnagiri and Satara— Sheet 203											
District Tanna— Sheets 81 $\frac{S.E.}{1,2,3,4}$, 133 $\frac{S.E.}{1,2,3,4}$,											
" 134 $\frac{N.E.}{1}$, $\frac{S.E.}{1,2,3,4}$, 136 $\frac{}{4}$		...	...	...	...	...	...	...	33	1,575	1,575
" 159 $\frac{S}{4}$ and 160 $\frac{N.E.}{3}$, $\frac{N.W.}{1,3}$, $\frac{S.E.}{1,3,4}$ and $\frac{S.W.}{1,2,3,4}$											
Districts Tanna, Nasik and Jawhar States— Sheets 135 and 161											
District Salara— Sheet 239											
District Ratnagiri— Sheet 173											
Districts Ratnagiri and Kolaba— Sheet 168		1=2	1=1	28	28	...	28	7	...	...	...
Districts Ahmednagar, Nasik, Poona, and Satara— Sheets 4, 12, 16 and 35											
Burma (Lower).											
Sheet 227 $\frac{N.E.}{1,3}$, $\frac{N.W.}{4}$, $\frac{S.E.}{1,2}$, and $\frac{S.W.}{4}$		1=4	1=4	6	20	...	20	6	...	...	...
Districts Bassein and Henzada— Sheets 140, 182, 184, 185											
Districts Hanthawaddy and Pegu— Sheet 115 N.E., N.W., S.E., and S.W.											
District Tharrawaddy— Sheets 77 $\frac{N.E.}{4}$, 93 $\frac{N.E.}{1,2,3,4}$, $\frac{S.E.}{1,2,3,4}$		...	...	...	...	...	...	...	30	3,700	3,700
" 94 $\frac{N.E.}{2,3}$, $\frac{S.E.}{2}$, N.E., N.W. S.E. and S.W.											
Sheets 95 $\frac{N.E.}{4}$ and 110 $\frac{N.W.}{1,3}$, $\frac{S.W.}{1}$											

OFFICE, CALCUTTA.

during the year 1886-1887—contd.

Silver and other Printing.			Heliogravure and Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	107 15 0	
...	...	...	...	2	2*	...	...	...	...	139 10 3	* 2 Pigment prints.
...	...	...	...	2	2	...	...	...	...	2,528 12 7	
...	...	...	...	...	...	...	...	...	...	449 3 7	
...	...	...	...	...	...	...	...	...	...	17 0 0	
...	...	...	...	...	...	...	...	...	...	110 10 5	
...	...	...	...	...	...	...	...	...	...	37 3 9	
...	...	...	...	...	...	...	...	...	...	168 2 6	Reprint
...	...	...	...	...	...	...	...	...	...	227 13 0	
...	...	...	...	...	...	...	...	...	...	1,010 1 3	
...	...	...	...	...	...	...	...	...	...	876 1 8	
...	...	...	...	...	...	...	...	...	...	159 7 2	
...	...	...	...	...	...	...	...	...	...	359 14 11	
...	...	...	...	...	...	...	...	...	...	191 13 7	
...	...	...	...	...	...	...	...	...	...	158 6 6	
...	...	...	...	...	...	...	...	...	...	81 13 9	
...	...	...	...	...	...	...	...	...	...	283 8 4	
...	...	...	...	...	...	...	...	...	...	621 14 9	
...	...	...	...	...	...	...	...	...	...	369 14 3	
...	...	...	...	...	...	...	...	...	...	297 9 6	
...	...	...	...	...	...	...	...	...	...	1,051 12 0	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.
Standard Maps—*contd.*		M. I.	M. I.								
District Bassein— Sheets 141, 186		1=2	1=2 / 1=1	28	28	...	28	7	...	...	...
District Bassein and Henzada— Sheets 66, 78, 80 and 81											
District Henzada— Sheet 183 N.E., N. W., S.E. and S. W.											
District Prome— Sheets 74, 92, 93 and 179		1=2	1=2 / 1=1	21	36	...	40	10	10	825	825
Districts Henzada and Prome— Sheet 77											
Districts Pegu and Tharrawaddy— Sheet 180—											
District Shwegyin— Sheets 124 and 126		1=2	1=2	8	32	...	32	8	8	400	400
" *125 N.E., N.W., S. E., and S. W.		1=2	1=2	...	...	...	8	4	...	...	...
" 123 S.E. and S.W. . . .		...	...	...	...	...	...	...	2	150	150
" 1 N.E., S.E., 2 N.E., S.E., 3 N.E.											
" 4 N.W., S.W., 5 N.W., S.W. .											
" 6 N.W. (S.E. Trans-frontier) .		4=1	4=1	12	48	...	48	12	35†	9,485	9,485
" 15 N.E., S.E.; 23 N.W. and S.W. (N.E. Trans-frontier) . .											
Central India and Rajputana.											
Sheets 219, 252, 384, 401, and 410 .		1=1	1=1	3	12	..	12	3	5	525	525
Cutch.											
Sheets 54, 55, 56 and 69 . . .		...	...	...	...	...	...	...	4	600	600
" 31, 32, 37, 38, 39 and 40 . .		1=2	1=1	24	24	...	24	6	...	...	...
Gujarat.											
Sheets 41 N.E./1,3, N.W./3,4, S.W./1,2,3,4 and 42 N.W./3		1=4	1=4	9	36	...	36	9	9	1,350	1,350
Sheets Joint Sections 1 and 2, 133 and 159		...	...	...	...	...	...	...	6	900	900
" 185 N.E./2,4, S.E./2 and 190 section 9.											
" 88, 89, 214, N.E., N.W., S.E. and S.W.		1=2	1=2 / 1=1	16	40	...	40	10	...	...	...
" 215 N.E., N. W., S.E., and S.W.											
" 41 S.W./1,2,3,4		1=4	1=2	4	4	...	...	...	...	...	...
Hooghly River Survey—											
Sheet 3, Sections F. H. . . .											
" 4 " L. N. O. P. . .											
" 5 " J. K. O. Q. . .											
" 1 " J. L. M. N. O. P. .											
" II " A. B. E. to K. . .		...	...	...	...	...	...	...	33	6,600	6,600
" IV " I. J. K. M. . .											
" V " E. L. P. . .											
" 1, 2, 3, 5, 6, 7, 8, 9. . . .		1=3	1=3	6	14	...	14	10	10	1,500	1,500
" 6, 7, 8 and 9.		1=6	1=6 / 1=6	4	16	...	16	...	...	...	...
Hyderabad.											
Sheets 201, 210, 211, 218, 219, 221.											
" 223, 225, (212, 213) . .											
" (208, 209, 216, 217) . .											
" (204, 205, 214, 215, 222) .		1=1	1=1	11	43	...	43	11	11	825	825
" (Kummumett Circar) . .											
Kathiawar.											
Sheet 25		1=2	1=1	4	4	...	4	1	...	...	...
" 79		...	...	...	...	...	...	1	1	150	150
Konkan.											
Sheets 161, 162 and 163 . . .		1=4	1=4	12	38	...	38	12	12	144	144
Mysore.											
Sheets 26, 49, 54, 58, 62, 67, 68 and 69 .		...	...	...	...	...	...	...	8	1,200	1,200
" 1, 11, 18, to 25, 27 to 30, 43 to 48, 50, 55 to 57, 65, 66 and 70 . .		1=1	1=1	27	108	...	108	29	27	3,850	3,850

OFFICE, CALCUTTA.

during the year 1886-1887—continued.

Silver and other Printing.			Heliogravure, & Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo-Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	371 1 6	
...	...	...	...	...	...	...	...	...	...	770 13 6	
...	...	...	...	...	...	...	...	...	...	555 1 8	*Negative of the 4 sections and photo-transfer of S.E. and S.W. were taken last year.
...	...	...	...	...	...	...	...	...	...	66 0 0	
...	...	...	...	...	...	...	...	...	...	44 6 1	
...	...	...	...	...	...	...	...	...	...	3,315 10 8	†Out of 35 plates 20 reprinted.
...	...	...	...	...	...	...	...	...	...	310 6 11	
...	...	...	...	...	...	...	...	...	...	165 12 3	
...	...	...	...	...	...	...	...	...	...	319 3 2	
...	...	...	...	...	...	...	...	...	...	851 14 0	
...	...	...	...	...	...	...	...	...	...	257 11 2	
...	...	...	...	...	...	...	...	...	...	528 0 0	
...	...	...	...	...	...	...	...	...	...	25 12 9	
...	...	...	...	...	...	...	...	...	...	908 6 9	
...	...	...	...	...	...	...	...	...	...	713 2 8	
...	...	...	...	...	...	...	...	...	...	180 0 0	
...	...	...	...	...	...	...	...	...	...	818 5 1	
...	...	...	...	...	...	...	...	...	...	52 12 9	
...	...	...	...	...	...	...	...	...	...	40 15 0	
...	...	...	...	...	...	...	...	...	...	667 10 2	
...	...	...	...	...	...	...	...	...	...	343 9 7	
...	...	...	...	...	...	...	...	...	...	2,570 12 0	

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.
Standard Maps—*contd.*		M. I.	M. I.								
North-West Provinces.											
Districts Agra and Aligarh, Sheet 37											
,, Aligarh, ,, 23											
,, Ballia and Sarun, ,, 218 and 220											
,, Ballia, Ghazipur and Shahabad, Sheet 219.	. . . .	1=2	1=1	30	30	...	30	5	...	...	...
,, Benares, Ghazipur and part of Shahabad, Sheet 211											
,, Ballia, Sheet 208											
,, Ballia and Sarun, ,, 217	. . . .	1=2	1=1	12	12	...	12	3	3	350	350
,, Ghazipur ,, 194											
,, Aligarh, Sheets, 36 N.E., N.W., S.E. and S.W.	. . . .	1=2	1=2	4	16	...	16	4	...	...	...
,, Ballia and Ghazipur, Sheet 209	. . . .	...	...	...	...	...	...	...	1	150	150
,, Ballia, Sarun and Shahabad, Sheet 221.	. . . .	1=2	1=1	4	4	...	4	1	...	...	...
North-West Provinces and Oudh.											
Sheet 56 A.	. . . .	1=1	1=1	1	4	...	4	1	...	...	...
,, 56 B.	. . . .	...	...	...	...	...	...	...	1	150	150
North-West Trans-frontier.											
Two Sheets	. . . .	4=1	4=1	2	8	...	8	2	2	250	250
Three ,,	. . . .	4=1	4=1	3	12	...	12	3	...	...	...
Punjab.											
Districts Hissar and Patiala State, Sheets 243, 257, 258.											
,, Hoshiarpur and Jullundur, Sheet 250.	. . . .	1=2	1=1	16	16	...	16	4	4	600	600
,, Hissar and Patiala State, Sheet 242.											
,, Bickaneer, Hissar, Loharu and Jind States, Sheet 261.											
,, Hissar and Karnal, Sheet 256											
,, Jullundur and Ludhiana, Sheet 252	. . . .	1=2	1=1	24	24	...	24	6	...	...	...
,, Ludhiana, Sheet 253											
,, Jullundur, ,, 268											
,, Delhi, Sheets 298, 299, 319 to 322	. . . .	1=1	1=1	6	24	...	24	6	...	...	...
Government Cattle Farm, Karnal, Sheets 1, 2, 3 and 4.	. . . .	1=8	1=8	4	16	...	16	4	4	400	400
Districts Hissar and Bickaneer State, Sheets 244, 259, 260.	. . . .	1=1 / 1=2	1=1	9	12	...	12	3	3	450	450
South Maratha Country.											
Sheets 275 and 276	. . . .	1=2	1=1	8	8	...	8	2	...	...	...
Total	. . . .	...	...	392	805	...	813	211	283	39,629	39,629
Index Maps.											
Andaman, Cutch, Damoh, Gujarat, Jubbulpore, Sambalpur, and South Maratha Survey.	. . . .	...	...	...	...	...	3	1	3	1,550	3,300
Burma Standard Sheets, Mirzapur, North-West Trans-frontier, and Raipur District.	. . . .	8=1 / 16=1	Reduced 12=1 / 16=1	4	4	...	4	1	3	1,550	2,200
Ajmere, Akyab, Basti, Bilaspur, Chhindwara, Darrang, Deccan, Gorakhpur, Kamrup, Mozufferpore, Narsinghpur, Saugor, and Seoni.	. . . .	...	...	...	...	...	...	...	8	4,050	5,800
Burma, Reconnaissance Sheets of,	. . . .	32=1	32=1	2	2	...	2	2	2	260	260
Burma, Standard Sheets of,	. . . .	31=1	Scale & Half	2	6	...	6	3	2	50	50
Hooghly River Survey	. . . .	4=1	6=1	1	1	...	1	1	1	100	100
Bombay Presidency (Original Index)	. . . .	...	Scale & Reduced	1	3	...	3	2	3*	125	125
Madras Survey, Sheet 1	. . . .	...	...	...	...	...	...	...	1	50	50
Bengal and Central Provinces Standard Sheets and North-Western Provintes and Oudh.	. . . .	32=1	52=1	3	3	...	3	2	4	1,200	1,550
Rajputana Survey	. . . .	...	...	...	...	...	1	1	3	1,050	550
Akyab, Cadastral Survey, Chhindwara, Narsinghpur, Saugor and Seoni Districts.	. . . .	8=1	12=1	3	3	...	3	1	...	...	...
Trans-frontier of India Sheets	. . . .	16=1	Reduced	1	1	...	1	1	1	450	450
Darrang, Kamrup, and Nowgong Districts, Cadastral Survey of,	. . . .	12=1	18=1	2	2	...	2	2	...	...	...

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during the year 1886-1887—continued.

Silver and other Printing.			Heliogravure and Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	381 14 2	
...	...	...	...	...	...	...	...	...	...	258 7 9	
...	...	...	...	...	...	...	...	...	...	211 3 2	
...	...	...	...	...	...	...	...	...	...	42 15 2	
...	...	...	...	...	...	...	...	...	...	53 1 7	
...	...	...	...	...	...	...	...	...	...	52 12 9	
...	...	...	...	...	...	...	...	...	...	40 15 0	
...	...	...	...	...	...	...	...	...	...	166 14 3	
...	...	...	...	...	...	...	...	...	...	158 6 6	
...	...	..	...	...	...	...	...	...	...	368 13 6	
...	...	...	...	...	...	...	...	...	...	316 12 6	
...	...	...	...	...	...	...	...	...	...	317 6 5	
...	...	...	...	...	...	...	...	...	...	329 13 11	
...	...	...	...	...	...	...	...	...	...	281 6 11	
...	...	...	...	...	...	...	...	...	...	105 9 6	
...	...	...	...	...	...	...	...	...	...	21,416 5 2	
...	...	...	...	...	...	...	...	...	...	190 8 5	
...	...	...	...	...	...	...	...	...	...	117 7 2	
...	...	...	...	...	...	...	...	...	...	386 2 10	
...	...	...	...	...	...	...	...	...	...	34 3 2	
...	...	...	...	...	...	...	...	...	...	86 13 8	
...	...	...	...	...	...	...	...	...	...	27 0 11	
...	...	...	...	...	...	...	...	...	...	69 14 7	* 1 Plate reprinted.
...	...	...	...	...	...	...	...	...	...	10 2 3	Reprint.
...	...	...	...	...	...	...	...	...	...	132 5 0	
...	...	...	...	...	...	...	...	...	...	79 12 2	
...	...	...	...	...	...	...	...	...	...	37 3 2	
...	...	...	...	...	...	...	...	...	...	40 10 5	
...	...	...	...	...	...	...	...	...	...	27 9 8	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Zinc plates transferred	Zinc plates printed.	Pulls.	Copies.
Index Maps—*contd.*		M. I.	M. I.								
Angul State, Damoh, Jubbulpore, Bilaspur, Gorakhpur and Southern Maratha Survey.		4= 1 8= 1 16= 1	8= 1 12= 1 24= 1	5	5	...	5	1	...	...	...
Bassein and Tarai Districts		6= 1	8= 1	2	2	...	2	1	...	...	...
Ajmere* Basti and Sambalpur Districts, Cadastral Survey of,		4= 1	2= 1 8= 1	2	2	...	2	2*	...	...	...
Sankarpur State, Survey operations in,		4= 1	6= 1	1	1	...	1	1	...	...	...
Raipur District, Sheets 2 and 3		8= 1	12= 1	2	2	...	2	2	1	25	25
Nagpur and Wardha Districts											
Gujarat		16=1	½	1	1	...	1	1	...	...	...
Total		...	...	32	38	...	42	25	32	10,460	14,460
Charts.											
Triangulation Charts of Central Provinces Topographical Survey.		4=1	4= 1	3	9	...	9	3	...	...	...
Triangulation Chart of Mysore Survey, Degree Sheet IX.		...	...	...	...	...	...	...	1	25	25
Total		...	...	3	9	...	9	3	1	25	25
Miscellaneous Maps and Plans.											
Arabia and Asia, Map of,		32=1	32=1	6	6	...	...	...	...	...	...
Basti District, Pargana Basti East		...	...	...	...	...	...	...	1	260	260
Do. Cadastral Map of (specimen map)		16=1	16=1	1	1	...	1	1	...	...	...
Beegah scale		...	scale	2	3	...	3	1	1	80	150
Bengal, Map of, (provincial) (original and duplicate)		...	..	2	...	...	...	...	...	...	...
Boundary between Garo hills and Mymensingh		1=2	1=2	1	5	...	5	2	2	100	100
Burma, Upper, Map of		16=1	16=1	2	5	...	5	2	2	1,100	1,100
,, ,, ,, (prelimimary) 1887											
,, ,, Distribution Map of		...	...	...	...	...	...	...	1	50	50
,, ,, Map of (2nd edition)		...	...	...	...	...	...	...	2	250	250
,, Township Yaw Rough Map of,		1=4	1=4	1	4	...	4	1	1	60	60
Darjeeling District, Sheet 43I		1=2	1=1	1	2	...	2	...	...	...	...
District Map of Simla		...	...	1	1	...	...	...	...	...	...
Extract from the Scientific American		...	Reduced	2	1	...	1	1	1	20	20
Headings of the Burma Survey (Cadastral)		...	...	...	...	...	...	...	...	400	1,170
India Sheet 2		32=1	...	1	...	...	...	...	...	...	...
,, Sheet 5 (original and duplicate)		32=1	...	2	...	...	...	...	...	...	...
,, Sheet 6 ,,		32=1	...	2	...	...	...	...	...	...	...
,, Map of, ,,		256=1	...	2	...	...	...	...	...	...	...
,, showing Railways open to traffic and under construction and under survey		...	...	...	...	...	...	...	1	125	125
,, showing Railways with Stations		...	...	...	...	...	...	...	...	200	200
Jacobabad to Chaman and adjoining country		16=1	16=1	1	1	...	1	1	1	100	100
Kheri District, main circuit Map, Sheets 6, 11, 12, and 13		...	...	9	9	...	9	9	9	54	54
Map showing Sind-Pishin Section of North-Western Railway and adjoining countries		4=1	4=1	...	...	...	...	...	...	90	90
Metric Table		...	...	...	...	...	...	...	1	20	20
Mysore Topographical Survey, compilation Map of		16=1	16=1	1	2	...	2	1	...	...	...
Naini Tal Municipality Map		...	...	...	...	...	...	...	...	60	60
Ordnance Survey, Sheets 5 and 6		...	...	...	...	...	...	...	...	...	...
Panoramic Profile of Hills near Naini Tal		...	...	1	2	...	4	...	...	...	...
Plans of proposed Photo. and Litho. offices		1=8		2	2	...	2	1	5	62	62
Pishin-Dera Ghazi Khan road from Sakhi Sarwar, *viâ Rokhinola*		feet 8=1	8=1	1	1	...	...	...	...	...	...
Portion of the Western Jumna Canals		12=1	14=1	2	1	...	...	...	...	...	...
Portion of Chart from Mud Point to South Bluff, Sheet 11		...	...	...	...	...	...	...	...	...	...
Quarter Atlas Sheet 6 S.E.		...	...	...	...	...	...	...	...	...	...
,, 9 S.E. and S. W.		...	...	2	...	...	...	...	...	...	...
,, 14 S.W.		4=1	4=1	2	1	2	...	...	...	...	...
,, 15 N.E., half of,		...	...	1	...	...	...	...	...	...	...
,, 28 S.E.		...	...	...	...	...	...	...	...	...	...
,, 38 S. W. and 39 S. W. (original and duplicate)		...	...	4	...	...	...	...	...	...	...
Quarter Atlas Sheet 76 S.W.		...	...	1	...	...	...	...	...	...	...
Quarter Atlas Sheet 79 S.W.		..	...	1	...	...	...	...	...	...	...
Relief Map of India		...	...	...	...	...	...	...	...	...	...
Scale of Contours		...	...	...	...	...	...	...	...	...	...
Shajahanpur District		...	...	...	...	...	...	...	1	100	100
Sholapur Municipality Map		...	...	...	...	...	...	...	...	150	150
Skeleton Map of Afghanistan, Assam, Baluchistan, Burma, Punjab and Sind Frontier		...	...	...	...	...	...	...	2	200	300

OFFICE, CALCUTTA.

during the year 1886-87—contd.

Silver and other Printing.			Heliogravure & Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-Typed.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	56 6 3	
...	...	...	...	...	...	...	...	...	...	27 4 9	
...	...	...	...	...	...	...	...	...	...	29 1 7	* 1 plate cancelled. Reprint.
...	...	...	...	...	...	...	...	...	...	15 4 9	
...	...	...	...	...	...	...	...	...	...	30 12 3	
...	...	...	...	...	...	...	...	...	...	13 3 3	
...	...	...	...	...	...	...	...	...	...	1,411 14 3	
...	...	...	...	...	...	...	...	...	...	119 6 6	
...	...	...	...	...	...	...	...	...	...	6 12 6	
...	...	...	...	...	...	...	...	...	...	126 3 0	
36	...	...	...	...	...	...	...	...	...	151 3 2	
...	...	...	...	...	...	...	...	...	...	50 11 0	
...	...	...	...	...	...	...	...	...	...	24 4 9	One proof taken only for experiment.
...	...	...	...	...	...	...	...	...	...	43 3 2	
...	...	...	...	...	...	...	2	...	...	90 0 0	
...	...	...	...	...	...	...	...	...	...	108 2 9	
...	...	...	...	...	...	...	...	...	...	285 14 0	
...	...	...	...	...	...	...	...	...	...	13 12 0	Reprint.
...	...	...	...	...	...	...	...	...	...	50 14 9	
...	...	...	...	...	...	...	...	...	...	62 4 2	
...	...	...	...	...	...	...	...	...	...	23 6 5	
...	...	...	...	1	1	...	...	...	...	42 0 0	
...	...	...	...	...	...	...	...	...	...	17 8 7	
...	...	...	...	...	...	...	...	...	...	30 0 0	
...	...	...	...	...	4	...	1	...	...	324 0 0	
...	...	...	...	...	...	...	2	...	...	729 0 0	
...	...	...	...	...	...	...	2	...	...	648 0 0	
...	...	...	...	...	...	...	2	...	...	121 6 2	
...	...	...	...	...	...	...	...	...	...	24 6 10	For record in S. G. O.
...	...	...	...	...	...	...	...	...	...	50 2 6	
...	...	...	...	...	...	...	...	...	...	32 7 5	For record in S. G. O.
...	...	...	...	...	...	...	...	...	...	240 0 0	
...	...	...	...	...	...	...	...	...	...	32 5 9	For record in S. G. O.
...	...	...	...	1	...	...	...	...	...	6 7 7	
...	...	...	...	...	...	...	...	...	...	29 6 5	
...	...	...	...	...	...	...	...	...	...	15 0 9	
...	...	...	1	...	1	...	...	...	...	528 0 0	
...	...	...	...	...	...	...	...	...	...	34 12 9	
...	...	...	...	...	...	...	...	...	...	60 3 0	
...	5	...	...	...	...	...	...	...	...	25 3 2	
...	2	...	...	...	...	...	...	...	...	14 1 7	
...	1	...	...	...	...	...	...	...	...	2 6 5	
...	...	...	...	...	6	...	1	...	...	504 9 7	
...	...	...	...	2	...	...	2*	...	...	291 9 7	*Matrix.
...	...	...	...	2	1	...	...	...	...	731 6 5	
...	...	...	2	...	3	...	...	...	...	564 9 7	
...	...	...	2	...	...	...	1	...	...	182 4 0	
...	...	...	...	...	...	...	4	...	...	583 3 2	
...	...	...	...	...	...	...	1†	...	...	145 12 9	†Duplicate.
...	...	...	...	...	...	...	1	...	...	182 4 0	Matrix.
...	...	...	...	...	...	...	...	...	...	13 8 0	
3	...	...	...	...	...	...	...	...	...	4 8 5	
...	...	...	...	...	...	...	...	...	...	38 9 8	
...	...	...	...	...	...	...	...	...	...	6 12 0	
...	...	...	...	...	...	...	...	...	...		
...	...	...	...	3	...	...	...	...	...	28 9 0	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Photozincographic Printing. Zinc Plates transferred.	Photozincographic Printing. Zinc Plates printed.	Photozincographic Printing. Pulls.	Photozincographic Printing. Copies.
Miscellaneous Maps and Plans—*contd.*		M. I.	M. I.								
Skeleton Map of Naga Hills		...	..	...	...	...	...	...	10	5	5
Skeleton Map of India		...	½	4	2	...	...	...	...	...	...
Specimen of Ordnance Survey Map		...	Enlarged	1	2	...	...	...	...	...	...
Specimen Map		...	½ and ¾	1	2	...	2	...	...	...	...
Specimen Chart		1=2	1=1	1	1	...	...	...	...	...	...
Specimen Plans and enlarged drawings		10=1	Enlarged	3	4	...	4	1	1	25	50
„ of Lines and Type		5=1	10=1	3	4	...	...	...	...	...	...
„ of hill shading, Ordnance Survey of Scotland		...	...	...	...	...	...	...	...	...	...
Standard Symbols for use on Maps		...	...	...	...	...	...	...	...	...	...
Stereographic Projection of the Northern Celestial Hemisphere		...	½	1	1	...	1	1	1	100	100
Theodolite subtense and compass subtense on stand		...	...	2	2	...	...	...	...	...	...
Vernacular titles for Cadastral Maps		...	...	3	...	...	...	...	...	...	...
Vertical Angle-book form		...	...	...	...	...	...	2	2	1,500	1,500
Viceroy's crest original and duplicate		...	...	2	...	...	...	...	...	...	...
Views in Holland (Specimen)		...	½	1	1	...	1	1	...	...	...
Reduction of standard sheets to Atlas scale		2=1	4=1	104	85	...	36	10	10	40	40
Experimental work—											
Heliogravure		...	...	2	3	4	...	...	...	...	...
Photo-collotype		...	...	3	4	...	...	...	...	...	...
Grained prints		...	...	1	1	...	...	...	...	...	...
Making tracing prints		...	...	...	...	...	...	...	...	...	...
TOTAL	...	...	...	187	160	6	84	36	55	5,181	6,146
ABSTRACT OF DEPARTMENTAL MAPS.											
General Maps		...	...	...	6	...	...	...	29	1,718	1,518
Provincial Maps		...	...	...	...	...	...	...	1	150	150
Divisional Maps		...	...	4	4	...	4	1	1	50	50
District Maps		...	...	100	122	2	120	40	43	8,800	21,450
Plans of Cities and Cantonments		...	...	1	2	...	2	1	50	4,875	4,875
Standard Sheets		...	...	392	805	...	813	211	283	39,629	39,629
Index Maps		...	...	32	38	...	42	25	32	10,460	14,460
Technical Charts		...	...	3	9	...	9	3	1	25	25
Miscellaneous Maps and Plans		...	...	187	160	6	84	36	55	5,181	6,146
Transfers and Proofs		...	...	...	...	...	...	...	...	2,032	...
TOTAL		...	...	719	1,146	8	1,074	317	495	72,920	88,303
Cadastral Maps.											
North-Western Provinces—											
Photo-zincographs		...	...	1,768	1,769	...	1,783	1,733	1,733	36,956	36,956
Zincographs		...	...	826	...	...	...	826	826	17,524	17,524
TOTAL		...	...	2,594	1,769	...	1,783	2,559	2,559	54,480	54,480
Burma—											
Photo-zincographs		...	...	307	307	...	319	476	476	18,124	18,124
Zincographs		...	...	71	...	...	...	71	71	2,414	2,414
TOTAL		...	...	378	307	...	319	547	547	20,538	20,538
Assam—											
Photo-zincographs		...	...	425	425	...	421	418	418	22,154	22,154
Zincographs		...	...	220	...	...	...	220	220	11,660	11,660
TOTAL		...	...	645	425	...	421	638	638	33,814	33,814
Bengal—											
Photo-zincographs		...	...	1	1	...	1	...	...	...	...
Zincographs		...	...	...	...	...	...	...	...	...	...
TOTAL		...	...	1	1	...	1	...	...	...	...
Transfers and Proofs		...	...	...	...	...	...	...	...	7,249	...
TOTAL		...	...	3,618	2,502	...	2,524	3,744	3,744	116,081	108,832

OFFICE, CALCUTTA.

during the year 1886-87—concluded.

Silver and other Printing.			Heliogravure & Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	16 3 0	
...	...	...	...	...	...	...	...	...	...	10 12 9	
...	4	...	...	...	...	...	...	...	...	12 5 0	
...	...	...	...	...	...	...	...	...	...	16 12 9	
...	...	...	2	...	2	...	...	...	...	95 6 5	
...	...	...	...	...	...	...	...	...	...	67 9 11	
...	...	...	...	...	5	...	...	...	...	44 6 5	
...	2	...	...	...	...	...	...	...	...	2 11 2	
...	...	...	...	...	...	...	...	...	...	10 12 9	
...	...	...	...	...	...	...	...	...	...	21 10 2	
8	...	...	...	...	...	...	...	...	...	17 8 0	
...	...	...	...	...	...	3	...	...	...	31 8 0	
...	...	...	...	...	...	...	...	...	...	99 9 7	
...	...	...	1	...	...	...	2	...	...	78 0 0	
...	...	...	...	...	...	...	...	...	...	13 3 2	
148	94	...	...	...	...	...	...	...	...	1,168 14 7	
...	...	...	4	11	36	...	...	...	...	427 2 8	
...	...	...	...	...	...	...	...	8	16	...	
...	10	...	2	...	2	...	...	4	12	40 8 0	
...	...	...	...	...	...	...	...	...	...	9 11 0	
195	118	...	16	14	61	3	21	12	28	9,463 0 7	
...	...	...	...	...	...	...	...	...	...	596 13 8	
...	...	...	...	...	...	...	...	...	...	19 3 3	
...	..	...	...	...	...	...	...	...	...	68 3 2	
...	...	...	...	2	2	...	...	...	...	2,528 12 7	
...	...	...	...	...	...	...	...	...	...	1,010 1 3	
...	...	...	...	...	...	...	...	...	...	21,416 5 2	
...	...	...	...	...	...	...	...	...	...	1,411 14 3	
...	...	...	...	...	...	...	...	...	...	126 3 0	
195	118	...	16	13	61	3	21	12	28	9,463 0 7	
...	...	...	...	...	...	...	...	...	...	...	
195	118	...	16	15	63	3	21	12	28	36,640 8 11	
...	...	...	...	...	...	...	...	...	...	26,644 14 0	
...	...	...	...	...	...	...	...	...	...	8,403 6 0	
...	...	...	...	...	...	...	...	...	...	35,048 4 0	
...	...	...	...	...	...	...	...	...	...	6,962 15 0	
...	...	...	...	...	...	...	...	...	...	807 10 0	
...	...	...	...	...	...	...	...	...	...	7,770 9 0	
...	...	...	...	...	...	...	...	...	...	8,403 3 0	
	...	...	...	...	...	...	...	...	...	3,272 4 0	
...	...	...	...	...	...	...	...	...	...	11,675 7 0	
...	...	...	...	...	...	...	...	...	...	7 3 0	
...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	7 3 0	
...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	54,501 7 0	

PHOTOGRAPHIC OFFICE, CALCUTTA.

Statement showing the Amount and Value of Work done for other Departments during the year 1886-87.

Name of Department.	Sheets or Subjects.	Negatives.		Photozincographic Printing.					Silver and other Printing.			Heliogravure and Electrotyping.					Photo-collotype.		Value.	Remarks.
		Direct Negatives.	Reversed Negatives and Transparencies.	Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electrotyped.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
																			R a. p.	
Asiatic Society of Bengal	13	7	4	6	6	3	1,750	3,500	2	2	...	...	...	...	...	...	7	1,799	488 0 0	
Accountant General, Bengal	...	...	...	...	...	1	160	160	...	...	...	...	...	...	...	...	...	...	39 10 0	
Archæological Survey, Madras	6	6	...	...	...	...	...	...	...	...	...	2	...	6	...	...	...	...	172 4 0	
Agent and Chief Engineer, Bengal Central Railway Company, Ld.	1	2	...	2	1	1	100	100	...	...	...	...	...	...	...	...	...	...	40 11 0	
Agent, Bombay, Baroda and Central India Railway	...	...	...	...	2	2	300	300	...	...	...	...	...	...	...	...	...	...	41 8 0	
Chief Commissioner, Burma	8	2	...	2	1	1	110	110	...	...	...	...	...	...	...	...	...	...	50 14 0	
Do., Assam	7	20	...	20	6	6	600	600	...	...	...	...	...	...	...	...	...	...	492 12 0	
Chief Engineer, Bengal Public Works Department	12	36	...	36	12	14	1,975	1,875	...	...	...	...	...	...	...	...	...	...	905 3 0	
Do., Baroda State Railway	...	...	...	29	16	16	4,800	4,800	...	...	...	...	...	...	...	...	...	...	935 10 0	From old negatives.
Chief Superintendent, Telegraph Stores	3	2	...	2	2	2	800	1,200	...	...	...	...	...	...	...	...	...	...	51 8 0	
Consulting Engineer for Railways, Lucknow	1	1	1	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	33 0 0	
Commissioner of Excise, Central Provinces	...	...	...	...	...	1	48	48	...	...	...	...	...	...	...	...	...	...	7 3 0	
Director General of Archæological Survey	7	8	2	...	...	1	675	675	...	...	...	4	...	11	...	...	7	4,431	685 7 0	
Do. of Telegraphs in India	2	2	...	2	1	1	100	100	...	...	...	...	...	...	...	...	...	...	32 12 0	
Do. of Railways	4	11	...	11	4	4	5,870	5,870	...	...	...	...	...	...	...	...	...	...	1,052 5 0	
Director of Geological Survey	23	10	...	10	3	3	2,100	2,800	74	...	...	...	...	...	...	...	...	...	243 6 0	
Executive Engineer, Quetta Division	1	7	...	7	4	...	...	...	...	...	...	...	...	...	...	...	...	...	131 2 0	
Do., Secunderabad Division	1	9	...	9	4	...	...	...	...	...	...	...	...	...	...	...	...	...	140 6 0	
Government of India, Revenue and Agricultural Department	...	...	...	...	...	1	230	230	...	...	...	...	...	200	...	...	...	...	74 13 0	
Do., Military Department	2	2	...	5	2	2	3,025	3,025	...	...	...	...	...	...	...	...	...	...	107 5 0	
Do., Foreign Department	11	18	...	13	6	6	386	386	485	...	...	...	...	...	...	...	...	...	1,481 12 0	
Do., Public Works Department	33	33	...	33	12	13	1,943	4,960	12	...	...	...	...	...	...	...	...	...	780 6 0	
Do., Legislative Department	2	2	...	...	...	...	...	...	24	...	...	...	...	...	...	...	...	...	21 10 0	
Government of Bengal, General Department	3	3	...	4	1	1	35	70	...	...	...	...	...	...	...	...	...	...	40 12 0	
Do., Public Works Department	6	1	...	1	2	3	513	503	...	2	...	...	...	...	...	...	...	...	60 0 0	
Government of Punjab, Public Works Department	11	22	...	26	11	23	1,810	970	...	...	...	...	...	...	...	...	...	...	810 12 0	
Do., Revenue Department	...	...	...	...	1	11	3,550	3,550	...	...	...	...	...	...	...	...	...	...	846 12 0	
Government of Bombay	8	8	...	8	2	...	...	...	...	...	...	...	...	...	...	...	...	...	105 10 0	

Government of North-Western Provinces and Oudh, P. W. D.	18	18	...	18	9	9	2,025	7,650	...	...	...	...	...	...	...	...	...	...	456	13	0
Gorakhpur Municipality	20	15	...	15	4	...	...	...	...	...	...	...	...	...	...	...	...	...	194	2	0
Health Officer to the Calcutta Municipal Corporation	4	4	...	1	...	...	...	...	...	3	...	...	...	...	...	...	...	...	30	12	0
Inspector-General of Military Works	25	64	...	64	18	14	4,450	6,700	...	...	...	...	...	...	...	...	...	...	1,637	2	0
Indian Museum	...	...	...	...	...	...	...	...	51	...	...	...	...	...	...	...	...	...	69	5	0
Kashmir Railway Survey	4	36	...	36	11	11	240	240	...	...	...	...	...	...	...	...	...	...	500	0	0
Lucknow Municipality	4	16	...	16	4	4	840	840	...	...	...	...	...	...	...	...	...	...	409	2	0
Master of the Mint, Calcutta	...	...	...	...	...	...	...	...	5	...	...	...	...	...	...	...	...	...	7	8	0
Manager, Rajputana-Malwa Railway	11	22	...	22	6	6	300	550	...	...	...	...	...	...	...	...	...	...	361	4	0
Do., North-Western Railway	1	1	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	19	3	0
Do., Dacca State Railway	1	1	...	1	1	1	60	60	...	...	...	...	...	...	...	...	...	...	36	12	0
Do., Eastern Bengal State Railway	2	8	...	8	2	1	100	100	...	...	...	...	...	...	...	...	...	...	130	13	0
Marine Survey of India	1	4	...	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	56	7	0
Meteorological Reporter, Government of India	25	18	...	15	7	4	1,800	3,600	6	3	...	...	...	...	...	...	...	...	685	9	0
Naini Tal Municipality	5	23	...	23	6	6	300	300	...	...	...	...	...	...	...	...	...	...	371	9	0
Port Officer, Calcutta	3	9	...	9	4	4	420	420	...	...	...	...	...	...	...	...	...	...	227	11	0
Port Commissioner	18	69	...	68	19	21	2,240	2,240	...	...	...	...	...	...	...	...	...	...	1,467	3	0
Quarter Master General in India	61	75	...	96	38	48	7,742	9,452	...	...	...	...	...	...	...	...	...	...	2,522	6	0
Secy. to the Commr., Reve. Sett., Land Records and Agri., Madras	2	...	2	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	115	3	0
Secretary to Board of Revenue, North-Western Provinces and Oudh	2	4	...	4	2	2	400	400	...	...	...	...	...	...	...	...	...	...	174	15	0
Do. to the United Service Institution, Simla	1	1	...	1	1	1	765	765	...	...	...	...	...	...	...	...	...	...	83	12	0
Settlement Officer, Mozufferpore	...	...	...	...	...	4	1,000	800	...	...	...	...	...	...	...	...	...	...	193	7	0
Sanitary Commissioner with the Government of India	2	...	5	...	...	...	...	...	...	...	...	...	2	6	...	...	...	...	138	0	0
Do. do. Bengal	12	12	...	12	2	2	852	852	...	...	...	...	...	...	...	...	...	...	379	8	0
Do. do. Central Provinces	1	1	...	1	1	1	280	280	...	...	...	...	...	...	...	...	...	...	42	9	0
Do. do. Hyderabad Assigned Districts	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	11	0
Superintendent, Government Printing, India	16	22	...	22	12	12	975	945	...	...	...	...	...	...	...	...	...	...	420	13	0
Superintendent, Carriage and Wagon Department, East Indian Railway	1	1	...	1	2	1	25	25	...	...	...	...	...	...	...	...	...	...	22	4	0
Superintendent, Royal Botanical Garden	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	350	191	15	0
Superintending Engineer, Mysore, Public Works Department	40	32	...	...	...	...	...	...	277	...	...	...	...	...	...	...	...	...	539	9	0
Sholápur Municipality	4	12	...	12	3	3	300	300	...	...	...	...	...	...	...	...	...	...	230	7	0
Special work done for trade and private individuals	15	15	2	24	8	8	642	1,127	177	...	...	...	2	3	...	...	...	...	479	6	0
TOTAL	466	697	16	701	261	279	36,636	73,478	1,113	10	...	6	7	229*	...	...	18	6,580	22,080	5	0

* Including 29 pigment prints.

GENERAL ABSTRACT.

Departmental Maps and Plans	719	1,146	8	1,074	317	495	72,920	88,303	195	118	...	16	16	63	3	21	12	28	36,640	8	11
Cadrastral Maps	3,618	2,502	...	2,524	3,744	3,744	116,081	108,832	...	...	...	...	...	...	...	...	...	...	54,501	7	0
Extra-Departmental Maps and Plans	466	697	16	701	261	279	56,636	73,478	1,113	10	...	6	7	229	...	...	18	6,580	22,080	5	0
GRAND TOTAL	4,803	4,345	24	4,299	4,322	4,518	245,637	270,613	1,308	128	...	22	23	292	3	21	30	6,608	1,13,222	4	11

PHOTOGRAPHIC OFFICE, CALCUTTA.

Statement showing Expenditure (Dr.) and Value of work done (Cr.) during the year 1886-87.

Dr.	R	a.	p.	R	a.	p.		R	a.	p.	R	a.	p.
Normal Establishment.													
Superintendent's salary	4,887	3	11				Departmental Maps and Plans	36,640	8	11			
Assistant Superintendent's salary	2,772	0	0				Miscellaneous Maps and Plans, extra-departmental	22,080	5	0			
				7,659	3	11					58,720	13	11
Establishment	30,961	5	8				Cadastral Maps, North-Western Provinces	35,048	4	0			
Rent of office and taxes	4,525	4	0				Cadastral Maps, Burma	7,770	9	0			
Contingencies	2,122	2	11				Cadastral Maps, Assam	11,675	7	0			
				37,608	12	7	Cadastral Maps, Bengal	7	3	0			
Cadastral Establishment.											54,501	7	0
Superintendent's salary	4,887	3	11				Old tin and packing cases sent to the Mathematical Instrument Office	175	7	0			
Assistant Superintendent's salary	2,772	0	0				Articles and stores supplied to other Offices of the Survey of India Department	20	1	6			
				7,659	3	11					295	8	6
Establishment	29,819	14	5				Stores and Materials supplied to other Departments	121	5	3			
Rent of office and taxes	3,426	6	0				Sale of unserviceable articles	96	13	0			
Contingencies	7,455	0	9				Pure silver recovered from silver residues	2,260	0	0			
				40,702	5	2					2,356	13	0
Chemicals and stores received from England	20,427	15	6										
Paper received from England	32,563	2	0										
				52,991	1	6							
Stores and materials from the Stationery Office	130	0	0										
Printing paper and cloth from Stationery Office	150	8	4										
				280	8	4							
Stores received from the Mathematical Instrument Office	114	2	0										
Articles repaired at Mathematical Instrument Office	187	3	0										
				301	5	0							
Cost of work done by Lithographic Office	2,934	6	0										
Paper and stores received from the Lithographic and Engraving Offices	315	12	0										
				3,250	2	0	Balance against the Department				34,580	11	8
Work done by the Foundry and Shell Factory	25	0	11										
				25	0	11							
Total				1,50,476	11	4	Total				1,50,476	11	4

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement of Departmental Work done during the year 1886-87.

Specification of Stone or Print.	Lithographic Printing.							Type Printing.				Value.	Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Stones.	Coloured copies.	Uncoloured copies.	Pages or items.	Pulls to each item.	Total Pulls.	Total Copies.		
		In. Mls.										R. a. p.	
General Maps.													
Transferred from Copper-plate.													
Rajputana Agency, in 2 sheets.	Additions and corrections made.	1 = 16	Double royal	2	2	...	75	...	...	150	75	318 8 0	
India, in 6 sheets, sheets Nos. 2, 4 and 6.	Ditto .	4 = 32	Dl. elephant	3	3	..	...	...	...	...	...	897 6 0	Not yet printed.
Drawn previously but printed during the present year.													
Canal Map of India, in 6 sheets.	Corrections made.	1 = 32	Ditto .	6	11	50	...	...	...	550	50	157 4 0	
India showing Density of Population.	Ditto .	2 = 80	Special .	1	3	620	...	...	...	1,860	620	597 14 0	
Reprint.													
India, showing the Progress of Imperial Surveys to 31st October 1886, to accompany Annual Report.	Corrections &c., made and colour stones prepared.	1 = 128	Imperial .	1	4	500	50	...	...	2,050	550	213 5 0	
Provincial Maps.													
Reprint.													
Skeleton Map of Punjab and Surrounding Countries.	...	1 = 32	Atlas . .	1	2	...	285	...	...	285	285	42 0 0	
District Maps.													
Drawn during the year.													
Ghazipur . . .	Drawn on transfer paper.	1 = 4	Imperial .	1	1	...	...	...	...	...	...	214 3 0	Not yet printed.
Transferred from Copper-plate.													
Assam—													
Newgong . . .	Additions and corrections made.	1 = 4	Double royal	4	8	...	...	...	...	...	...	205 12 0	Not yet printed.
Sibsagar . . .	Ditto .	1 = 4	Ditto .	1	1	...	...	...	...	...	...	72 6 0	Ditto.
Bengal—													
Burdwan . . .	Additions and corrections made.	1 = 4	Atlas . .	1	2	...	...	...	...	...	...	281 6 0	Not yet printed.
Chumparun . . .	Ditto .	1 = 4	Ditto .	1	1	...	...	...	...	...	...	121 12 0	Ditto.
Moorshedabad . .	Ditto .	1 = 4	Ditto .	1	1	...	...	...	...	...	...	142 12 0	Ditto.
Sonthal Pergunnahs .	Ditto .	1 = 4	Dl. elephant	1	1	...	300	...	...	300	300	366 9 0	
Central Provinces—													
Jubbulpore . . .	Additions and corrections made.	1 = 4	Dl. elephant	1	1	...	...	...	...	...	...	109 3 0	Not yet printed.
Transferred previously but printed during the present year.													
Khoolna	Further corrections made.	1 = 4	Atlas . .	1	1	...	100	...	...	100	100	63 13 0	
Jessore	Ditto .	1 = 4	Ditto .	1	1	...	150	...	...	250	150	83 5 0	
Hoshangabad . . .	Ditto .	1 = 4	Antiquarian	1	4	...	250	...	...	150	150	490 15 0	
24-Pergunnahs . .	Ditto .	1 = 4	Atlas . .	1	1	...	250	...	...	150	150	58 9 0	
Nuddea	Ditto .	1 = 4	Ditto .	1	2	...	250	...	...	250	250	203 13 0	
Reprint.													
Cachar	Corrections, &c., made.	1 = 4	Double royal	1	1	...	250	...	...	150	150	106 10 0	
Carried over .	...	...	...	28	58	2,170	1,560	...	...	6,045	2,730	4,385 5 0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement of Departmental Work done during the year 1886-87—contd.

Specification of Stone or Print.	Lithographic Printing.							Type Printing.				Value.	Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Stones.	Coloured Copies.	Uncoloured copies.	Pages or items.	Pulls to each item.	Total Pulls.	Total Copies.		
		In. Mls.										R a. p.	
Brought forward	...	...	...	28	38	1,170	1,550	...	...	6,045	2,730	4,385 5 0	
Atlas Sheet.													
Transferred from Copper-plate.													
Quarter-Sheet No. 47 S. E.	Corrections, &c., made.	1 = 4	¼ Atlas	1	1	...	50	...	...	50	50	89 14 0	
Standard Maps.													
Drawn during the year.													
Oudh Revenue Survey, Sheets Nos. 131, 158, and 159.	Drawn on transfer paper.	1 = 1	Double royal.	3	3	...	...	...	...	...	...	1,285 2 0	Not yet printed.
Oudh Revenue Survey, Sheet No. 152.	Re-drawn on transfer paper.	1 = 1	Ditto	1	1	...	...	...	...	...	...	592 3 0	Ditto.
District Mymensingh, Sheet No. 362.	Drawn on transfer paper.	1 = 1	Ditto	1	1	...	...	...	...	...	...	546 0 0	Ditto.
District Jalpaiguri, Sheet No. 293.	Re-transfer made, with corrections.	1 = 1	Ditto	1	1	...	...	...	...	...	...	25 3 0	Ditto.
Drawn previously but printed during the present year.													
District Jalpaiguri, Sheets Nos. 293, 294, 295, 315, 316, 338 and 339.	Corrections, &c., made.	1 = 1	Double royal.	7	7	...	1,300	...	...	1,300	1,300	1,207 1 6	
Oudh Revenue Survey, Sheets No. 86, 87, 101, 118, 119, 122, 132, 133 and 134.	Ditto	1 = 1	Ditto	9	9	...	1,800	...	...	1,800	1,800	4,260 9 0	
Index Maps.													
Reprints.													
Index to the Sheet Map of North-Western Provinces.	...	1 = 32	Imperial	1	1	...	100	...	...	100	100	8 4 0	
Index map, No. 8 Party, on the scale of 1" = 1 mile, to accompany Annual Report.	Corrections made and colour stone prepared.	...	Foolscap	1	2	500	50	...	...	1,050	550	65 7 0	
Index to the Indian Atlas showing the state of the engraving and materials for engraving to 1st October 1886, to accompany Annual Report.	Ditto	1 = 256	Ditto	1	2	500	50	...	...	1,050	550	69 15 0	
Index to the Indian Atlas showing the Sheets that have been published to 1st October 1884, to accompany Annual Report.	Ditto	1 = 256	Ditto	1	2	500	50	...	...	1,050	550	66 10 0	
Miscellaneous maps	...	...	...	30	32	220	8,251	...	...	8,352	8,471	595 6 0	
Departmental forms	...	...	...	45	46	...	86,710	...	...	98,478	86,710	8,275 0 6	
Total	...	...	...	130	146	2,890	99,921	...	...	119,275	102,811	21,472 0 0	
Circular Orders	...	...	...	...	...	...	...	35	4,800	...	3,550	186 1 0	
Memoranda, &c.	...	...	...	...	...	...	...	485	146,777	...	135,243	2,498 15 0	
Forms, &c.	...	...	...	...	...	...	...	659	655,337	...	251,886	8,179 14 0	
Transfers for headings, foot-notes, references of published maps.	...	...	...	...	...	...	...	5,151	34,207	...	34,207	3,473 5 0	
Four Rubber Stamps	...	...	...	...	...	...	...	...	...	..	...	21 0 0	
Total	...	...	...	...	...	...	...	6,330	841,121	...	424,886	14,359 3 0	
Total Value	...	...	...	...	...	...	...	...	...	...	...	35,831 3 0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement shewing the Amount and Value of Work done for other Departments during the year 1886-87.

Name of Department.	Lithographic Printing.						Value.			Remarks.
	Sheets or subjects.	Stones.	Coloured copies.	Uncoloured copies.	Total pulls.	Total copies.	R	a.	p.	
Archæological Survey of India	21	15	...	14,280	10,200	14,280	852	2	0	
Asiatic Society of Bengal	6	3	...	4,545	2,295	4,545	375	13	0	
Board of Revenue, Lower Provinces	1	1	...	600	600	600	53	2	0	
Calcutta Municipality	15	17	2,200	5,700	9,100	7,900	716	2	0	
Central Provinces Government	3	3	...	2,805	2,805	2,805	269	1	0	
Ditto, Settlement Department	3	3	...	2,000	2,000	2,000	474	3	0	
Consulting Engineer, Government of India, for Guaranteed Railways.	8	8	300	1,332	1,878	1,632	338	9	0	
Conservator of Forests, Punjab	1	1	...	12	12	12	3	3	0	
Chief Commissioner, Burma	1	2	...	...	...	...	62	6	0	Not yet printed.
Commissary General-in-Chief	10	7	...	3,205	2,102	3,205	286	1	0	
	2	1	...	...	...	...	3	0	0	Not yet printed.
Deputy Commissioner, Ningyan District	9	9	...	27	27	27	19	15	0	
Director of Land Records and Agriculture, Assam	1	1	...	200	200	200	36	11	0	
Director of Military Education in India	4	6	900	...	1,400	900	421	2	0	
Executive Engineer, Bhamo Division	3	3	...	300	300	300	79	2	0	
Ditto, Pishin Irrigation Division	1	1	...	24	24	24	4	13	0	
Ditto, Rangoon Division	1	1	...	110	110	110	341	7	0	
Ditto, West Berar Division	1	4	...	55	220	55	656	12	0	
Geological Survey of India	6	10	2,770	1,230	9,540	4,000	1,085	9	0	
Government of India, Financial Department	1	1	...	...	...	...	28	12	0	Not yet printed.
Ditto, Foreign Department	52	40	110	3,359	1,595	3,469	1,329	11	0	
	4	4	...	...	...	...	61	2	0	Not yet printed.
Ditto, Home Department	4	3	...	629	425	629	273	5	0	
Ditto, Military Department	14	7	...	910	470	910	142	13	0	
Ditto, Revenue and Agricultural Department.	20	29	...	1,118	2,099	1,118	599	5	0	
Government of Bengal	17	16	4,350	1,164	6,764	5,514	631	5	0	
Ditto, Public Works Department	14	9	205	1,309	1,659	1,514	461	9	0	
Government, North-Western Provinces and Oudh, Public Works Department.	1	2	715	...	1,430	715	156	2	0	
Government, Punjab	2	2	...	443	443	443	227	2	0	
Ditto, Public Works Department, Irrigation Branch.	3	3	...	4,400	4,400	4,400	401	9	0	
Ditto, Finance Department	3	6	565	...	1,130	565	189	9	0	
Ditto, Settlement Department	1	1	...	1,360	1,360	1,360	297	4	0	
General Superintendent, Horse and Mule-Breeding Operations in India.	1	3	105	...	315	105	55	15	0	
General Officer Commanding Upper Burma Field Force.	1	1	...	200	200	200	105	0	0	
Honorary Secretary, Lady Dufferin's Fund	1	5	2 000	...	10,000	2,000	182	2	0	
Inspector General of Civil Hospitals, Punjab	1	2	225	...	450	225	95	14	0	
Meteorological Reporter, Government of India	27	24	1,040	16,710	16,420	17,750	1,852	1	0	
	3	3	...	...	...	...	176	6	0	Not yet printed.
Ditto ditto, ditto Bengal	2	2	...	11,492	11,492	11,492	135	0	0	
Ditto ditto, ditto Bombay	1	1	...	500	500	500	25	10	0	
Marine Survey of India	2	1	...	110	55	110	58	12	0	
Medical College	1	1	...	50	50	50	6	0	0	
Miscellaneous maps, plans, &c.	5	5	...	3,025	3,025	3,025	248	0	0	
Military Secretary to Viceroy	1	1	...	20	40	20	25	12	0	
Magistrate of Beerbhoom	1	1	...	600	600	600	20	8	0	
Officer in charge Nicobar Islands	1	1	...	...	...	...	24	0	0	Not yet printed.
Ordnance Department, India	6	2	...	1,224	408	1,224	131	1	0	
Officer Commanding Presidency Volunteers	6	2	...	220	660	220	71	10	0	
Quarter Master General in India	89	55	...	5,962	4,177	5,962	3,048	6	0	
	9	17	...	...	...	...	3,315	6	0	Not yet printed
Secretary, Public Service Commission	7	4	...	...	...	...	117	6	0	Ditto.
Sanitary Commissioner, Government of India	8	7	500	3,800	3,700	4,300	444	14	0	
	3	4	...	...	...	...	262	8	0	Not yet printed.
Secretary for Berar to the Resident at Hyderabad.	9	7	...	1,415	1,015	1,415	364	8	0	
Surgeon-General, Her Majesty's Forces, Bengal	9	6	...	2,308	1,408	2,308	278	7	0	
Superintendent, Government Printing, India	2	3	2,030	1,325	5,385	3,355	164	14	0	
Ditto, Royal Botanical Gardens	26	26	...	9,500	9,500	9,500	970	10	0	
Stationery Office	9	8	...	4,033	3,933	4,033	348	8	0	
Store-keeper, Burma State Railway	1	1	...	1,255	1,255	1,255	144	8	0	
Telegraph Department, India	39	18	...	6,480	2,080	6,480	532	3	0	
	12	7	...	...	...	...	300	0	0	Not yet printed.
Traffic Superintendent, Rajputana-Malwa Railway.	1	1	...	2,605	2,605	2,605	31	15	0	
Total	517	438	18,015	123,951	143,861	141,966	24,416	5	0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement showing Expenditure (Dr.) and Value of Work done (Cr.) during the year 1886-87.

DR.

	R	a.	p.	R	a.	p.
Superintendent's salary	4,887	3	11			
Assistant Superintendent's salary	2,772	0	4			
Establishment	33,924	11	4			
Office rent and taxes	3,879	0	0			
Contingencies	1,140	15	7			
				46,603	15	2
Lithographic drawing and printing materials received from England	839	8	2			
Type-printing materials received from England	422	8	7			
Miscellaneous type received from England	68	13	10			
Paper received from England	2,515	9	20			
Hand lever perforating machine, &c., received from England	85	9	10			
				3,632	2	3
Paper received from Stationery Office	9,148	9	3			
Miscellaneous articles received from Stationery Office	96	2	11			
				9,244	12	2
Type received from the Engineer-in-Chief, Benares-Pooree Railway Survey	25	12	0			
				25	12	0
Instruments received from Mathematical Instrument Office	13	2	0			
Cost of repair of articles at Mathematical Instrument Office	105	15	0			
				119	1	0
				59,625	10	7
Balance in favour of the Department				872	8	2
				60,498	2	9

CR.

	R	a.	p.	R	a.	p.
Standard and other maps and plans issued to the Survey of India Department	12,601	9	6			
Miscellaneous maps issued to the Survey of India Department	595	6	0			
Departmental Forms	8,275	0	6			
				21,472	0	0
Miscellaneous maps and plans, extra-departmental	24,416	5	0			
				24,416	5	0
Work done in Type Department	14,359	3	0			
				14,359	3	0
Paper supplied to Photo. and other offices of the Survey of India Department	113	15	9			
Old tin and packing cases sent to Mathematical Instrument Office	25	15	0			
				139	14	9
Unserviceable type sent to Government Printing, India	58	10	0			
Sale of waste paper	52	2	0			
				110	12	0
				60,498	2	9

MATHEMATICAL INSTRUMENT OFFICE.

TABLE A.

Detail of issues to, and receipts from, Provinces and Departments during financial year 1886-87.

Provinces and Departments.	RECEIPTS.	ISSUES.	DEBITS.	CREDITS.
	Value.	Value.	Value.	Value.
	₹	₹	₹	₹
Archæological Survey	...	199	199	...
Assam	5,348	4,878	...	470
Bengal, Civil	12,332	12,615	283	...
„ Military	1,603	9,767	8,164	...
Bombay, Civil	...	358	358	...
„ Military	355	2,860	2,505	...
Burma	2,154	35,113	32,959	...
Central India	175	147	...	28
Central Provinces	18,546	1,858	...	16,691
Forests	211	2,197	1,986	...
Gazetteers and Statistical	...	2	2	...
General Administrations, Foreign States	...	58	58	...
Geological Survey and Museums	60	201	141	...
Guaranteed Railways	1,587	185	...	1,402
Hyderabad P. W. Department	...	273	273	...
Law and Justice (Port Blair and Nicobars)	...	55	55	...
Madras, Civil	2,860	5,494	2,634	...
„ Military	7,432	11,176	3,744	...
Marine	151	1,540	1,389	...
Meteorological Department	427	2,403	1,976	...
Mint	...	36	36	...
North-Western Provinces and Oudh	449	1,269	820	...
Political	4,945	4,966	21	...
Punjab	66	4,397	4,331	...
P. W. D. Military Works	246	2,374	2,128	...
„ N. W. State Railway	3,751	1,874	...	1,877
„ Coorg	...	7	7	...
Rajputana-Malwa Railway	...	2	2	...
Rajputana P. W. Department	2	142	140	...
Sindh-Pishin and Bolan State Railway	1,262	651	...	611
Survey Department	23,291	79,952	56,661	...
Telegraph	...	331	331	...
TOTAL	87,253	1,87,377	1,21,203	21,079
NET DEBIT	...	...	1,00,124	
Cash Sales	...	6,893	6,893	
GRAND TOTAL	87,253	1,94,270	1,07,017	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B.

Instruments, &c., purchased in the local market during the financial year 1886-87.

	No.	Value.
Instruments.		₹ a.
Barometers, aneroid, small	4	257 12
Camera lucida	1	25 0
Clinometers, Watkin's	6	110 4
Compasses, drawing, common, brass, 5″	30	37 8
„ „ „ „ 6″	70	105 0
„ „ „ electrum 5″	17	25 6
„ magnetic, pocket, in brass cases	11	137 8
„ prismatic, card, 2″	1	22 0
„ „ Hunter's pattern	4	110 4
Clinometers, compasses, Watkin's	3	195 0
Hygrometers, Mason's	5	67 8
Instruments, drawing, mathematical, brass, 3rd sort	9	168 6
„ „ „ electrum, 3rd sort	6	129 0
Lamps, Bull's eye	23	101 0
Lenses, reading, 1″	12	9 3
„ „ 1½″	3	4 8
Levels, spirit, in wooden cases, 12″	5	10 10
„ „ „ „ 10″	1	2 0
Machines, map-printing, Ordnance pattern	6	255 0
Planimeters, electrum	3	155 0
Protractors, plain, semi-circular horn	2	2 11
„ rectangular, ivory, 6″	53	184 10
„ „ wooden, 6″	20	21 8
Pins for chains, common pattern	6,000	468 12
„ „ Revenue Survey pattern	1,000	187 8
Rules, carpenter's, boxwood, 2′ 2-fold, 2′ 4-fold, and 3′ 4-fold	138	93 4
„ parallel, bar, ivory	3	9 0
„ sight, for plane tables	275	825 0
Scales, horn	400	265 2
„ offsets, single, wooden	1	0 8
„ plotting „ „	1	4 0
Squares, optical, German pattern	200	1,300 0
Stands for plane-tables	275	1,925 0
Stands for telescopes	1	7 12
Tapes, measuring, 25 feet	1	3 0
„ „ 66 „ metallic	1	3 0
„ „ steel, pocket and others	5	90 0
Telemeters	1	47 8
Thermometers, chemical or traveller's	15	84 12
„ maximum and minimum on same board	3	33 0
„ spare, for Syke's hydrometers	13	40 0
„ grass	3	33 0
Watches, common	6	120 0
„ stop	4	260 0
TOTAL	8,641	7,936 12
Books.		
Griffin's Chemical Handicraft	1	2 7
„ Scientific „	1	2 2
Text Book of Steam Engine	1	4 10
Manual of Surveying	6	72 0
Nautical Almanacs	20	44 14
Tables, Logarithmic, Hutton's	6	43 6
Stanley's Drawing Instruments	1	3 1
Loome s Treatise on Meteorology	1	6 2
TOTAL	37	178 10

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*continued.*

Instruments, &c., purchased in the local market—continued.

	No.	Value.
Sundries.		₹ a.
Glasses for pluviometers	12	48 0
Numbers for chains	950	267 3
Pencil leads for instruments	3	6 0
Telescopes for range finders	6	44 10
Trunks, mule, leather	4	58 0
Cases, leather	24	84 0
Typing ink	2	5 8
Glass ink-bottles	36	5 7¼
Glass bottles for hydrometers	24	12 0
Horn sheets	100	50 14
Sponges	2	0 12
Numbers for chains, iron, single	500	15 10
Penknife, pocket	1	1 0
Eraser	1	0 3
TOTAL	1,665	599 3¼
BOOKS	37	178 10
INSTRUMENTS	8,641	7,936 12
GRAND TOTAL	10,343	8,714 9¼

TABLE C.

List of Instruments, &c., manufactured in Workshop during the financial year 1886-87.

	Number.	Value.
Instruments.		₹ a.
Bars, standard, steel	3	90 0
Boards, drawing, deal, large	24	301 0
" " " small	5	50 0
" " mahogany, large	1	18 0
Chains, measuring, 30 and 33 feet	175	800 0
" " 66 "	635	5,397 8
" " 100 "	50	500 0
" " other sizes and sorts	145	1,107 0
Clinometers	3	105 0
Compasses, magnetic, for plane tables, 5″ needles	77	1,018 0
" " " 6″ "	25	375 0
" prismatic, silver ring 4″	7	280 0
" surveying, Bengali	3	48 0
" " English	5	325 0
Curves, railway, zinc, single	4	8 0
Glasses, copying or tracing	7	266 8
Hold-alls	24	264 0
Lamps, referring	12	45 0
Pens, dotting	2	2 0
Plane tables, deal	364	3,582 0
" " military pattern	4	30 0
Pluviometers, Symon's pattern	97	1,258 0
Protractors, card board, 5″ and 12″	800	225 0
Pins for chains, common pattern	1,500	148 7
Rods, measuring, wooden	142	256 0
Rules, sight, for plane-tables	70	313 0
" brass, for military plane tables	6	60 0
Carried over	4,100	16,881 0

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C—*continued.*

List of Instruments, &c., manufactured in Workshop—continued.

	Number.	Value. ₹	a.
Brought forward	4,100	16,881	0
Scales, diagonal, cardboard	2,000	312	8
„ „ metal	200	250	0
„ engine divided cardboard, single	1,000	187	8
„ horn	100	75	0
„ offsets, single, ivory and slips	165	61	14
„ plotting, single, metal	7	16	0
Sectioner, dead beat Macginnes's	1	18	6
Squares, optical, German pattern	6	38	0
Staves, levelling, Roorkee pattern, double	6	144	0
„ „ telescopic and Sopwith's	51	780	0
Sundials	1	75	0
Stands for compasses, prismatic	7	105	0
„ „ surveying, Bengali	3	19	8
„ „ „ English	5	81	0
„ Heliotropes	3	30	0
„ plane-tables	50	350	0
„ thermometers	1	3	4
TOTAL	7,796	19,419	7
Sundries.			
Boxes and cases, block tin and tin	21	33	0
„ of sorts	4	3	12
Cases, packing	723	2,748	11
Doolies	10	17	8
Gauges, writing	6	11	14
Numbers for chains, brass, single and sets	85	118	12
Tubes, tin and zinc	76	60	3
Ink rollers, small	22	66	0
Plummets	24	31	8
Washers, brass	540	11	4
Cases, leather	12	36	0
Padded boards for thermometers	6	18	0
Spare rods for raingauges, country pattern	3	10	8
Canvas bags, waterproof, lined	12	72	0
Needles for compasses	4	8	0
Gauges for testing raingauges	12	90	0
Rods for raingauges	80	240	0
Pads for grass thermometers	6	18	0
Bohenbergar eye-piece	1	30	0
Reservoir for raingauge	1	2	6
Handles for chains	40	22	0
Head piece for plane tables	1	2	4
Discs with iron clamp	12	14	8
Hammers	30	16	0
Type frames	2	60	0
Wheels as per sample	2	30	0
Sectional electrum	1	32	6
Reflecting telescope stand	1	200	0
Scales, electrum, for levels	12	26	5
TOTAL	1,749	4,030	13
Add—Total of Instruments	7,796	19,419	7
SUM TOTAL	9,545	23,450	4
Brass Castings, &c., for Material Stock	...	1,556	0
GRAND TOTAL	..	25,006	4

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D.

List of Principal Instruments repaired in Workshop during the financial year 1886-87.

Instruments.	Number.
Anemometers	30
Arithmometers	2
Balance, electrical	1
Barometers, of sorts	69
Boards, drawing, of sorts	25
Chains of sorts	51
Chronometers	4
Clinometers	3
Compasses, Azimuth	2
Compass cards, of sorts	1
Compasses, bow pen, of sorts	70
„ bow pencil	2
„ circular	3
„ drawing, of sorts	147
„ magnetic, for plane-tables	64
„ mining	9
„ magnetic pocket	20
Compass pillar	1
Compasses, prismatic, of sorts	61
„ proportional	9
„ ship	7
„ surveying of sorts	62
Declinometer	1
Fiducial edge	1
Gauges, of sorts	6
Glasses, binocular	6
„ magnifying	1
Hand press	1
Heliographs	13
Heliotropes	1
Hydroclinometers	2
Hydrometers	77
Hygrometers	39
Instruments, drawing, of sorts	39
Lamps Bull's-eye	1
„ referring	2
Lenses, of sorts	1
Levels, of sorts	68
Machines, hand-printing	2
Magnets	2
Microscopes, of sorts	4
Micrometers	3
Mirrors, of sorts	10
Meter, current	1
Opiesometer	1
Padded boards	3
Pens, double, of sorts	3
„ drawing, of sorts	145
Pentagraph, of sorts	1
Perambulator	1
Pins for chains	290
Plane-tables	21
Planimeters	15
Pluviometers	10
Pointers station	5
Protractors, of sorts	14
Quadrants, gunner's	7
Quintants	4
Range finders	31
Rules, of sorts	16
„ sight, for plane-tables	32
Scales, of sorts	22
Scales, letter-weighing	1

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D—*continued.*

List of Principal Instruments repaired in Workshop—continued.

Instruments.	Number.
Sextants, of sorts	7
Squares, optical	93
Stands for compasses of sorts	52
„ for heliographs	14
„ for heliotropes	...
„ for levels	35
„ for plane-tables	14
„ for range finder	1
„ for theodolites	22
Staves, of sorts	69
Subtense compass	1
Tapes, of sorts	50
Telescopes, of sorts	65
Theodolites, of sorts	59
Thermometers, of sorts	49
Typeholder	2
Type hand-press	2
Watches, of sorts	2
Wind vances	3
TOTAL OF PRINCIPAL INSTRUMENTS REPAIRED	2,086
MINOR INSTRUMENTS REPAIRED	405
TOTAL OF ALL INSTRUMENTS REPAIRED	2,491

Profit and Loss Account of the Workshop for the financial year 1886-87.

Debits.	R	a.	Credits.	R	a.
Workshop Establishment, less proportion debitable to the Store Branch for cleaning and adjusting serviceable instruments	34,668	4	By repairs for public officers	11,808	12
One-third of office establishment	2,408	15	„ „ „ Stock	29,472	8½
Workshop contingencies as distinguished from materials purchased	598	11	„ Manufactures for Stock—		
Value of Materials—					
For special work	12,946	10	"Instruments"	20,683	13
„ General Workshop use	437	13			
For Manufacture of packing cases	1,659	15	"Packing Cases"	2,766	7
Paid for repairs	1,040	8			
Wear and tear of plant	1,206	0	„ Manufactures for materials	1,556	0
Half of rent at R325 per mensem	1,950	0			
Printing and stationery	206	1			
Four per cent. on value of tools and plant amounting to R60,913-3	2,436	8	Work done for Workshop, Store and Correspondence Branches of Office	326	0
Workshop profit	7,845	6½	Work on prepayment	791	3
TOTAL	67,404	11½	TOTAL	67,404	11½

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Extract from the Narrative Report of MR. W. H. COLE, *M.A., in charge Computing Section.*

The following tabular statements exhibit the money value of the work performed by the Computing Section during the Survey year 1886-87.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Computing Section.

DR.			CR.		
	₹	₹		₹	₹
Deputy Superintendent's salary	8,967		Work done for the Survey of India Department as shown in the following table.	48,371	
Assistant Superintendent's salary	5,380				
Establishment	33,048				
Contingencies and travelling allowance.	535	47,930			48,371
Stationery	50	50	Extra Departmental work done.	288	
Library, books and periodicals, also for binding Syl. Vol. VIIA.	679	679			288
TOTAL	...	48,659	TOTAL	...	48,659

Statement of Departmental work done by the Computing Section.

No.	Class.	Value.
		₹
1	Records, Library (including cost of purchase of books, &c., and binding of syl. vols.)	2,458
2	Computations	16,069
3	Accounts, returns, correspondence	3,104
4	Supply of data, &c.	1,101
5	Preparation of press copy	7,803
6	Examination of press proofs	3,421
7	Do. charts, &c.	362
8	Protection of stations	1,583
9	Miscellaneous	10,881
10	Meteorology and general science	1,877
	TOTAL	48,659

Statement showing the value of work done for other Departments by the Computing Section.

Names of other Departments.	Value.
	₹
Quartermaster-General's Department in India	37
Meteorological Department	251
TOTAL	288

Some explanation of the various items will now be given.

CLASS 1, RECORDS, LIBRARY, &C.—The records of all the survey operations appertaining to the Trigonometrical Branch, from the time of Colonel Lambton to the present date, find a resting-place in this office, where they are carefully stored and periodically inspected. Further, as each instalment is received it is closely examined, indexed, registered, and a detail receipt furnished to the executive officer from whom it comes. The custody of the Library, which now contains over four thousand volumes and pamphlets of a scientific character, also comes under this head, as well as the cost of books and periodicals purchased during the year, both for the Library itself and also for the several survey parties of the Trigonometrical Branch. Further, the binding of three hundred and fifty copies of a Synoptical Volume has been charged to this account.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

CLASS 2, COMPUTATIONS.—The principal operations under this heading have been—

(1) The completion of the final reduction of the principal triangulation of the South-West Quadrilateral which was nearly finished last year. The whole of the principal triangulation of India between the meridians of 67° and 92° has now been finally reduced.

(2) The reduction of the secondary triangulation of the Assam Longitudinal Series and Assam Valley Series of the North-East Quadrilateral. This has been steadily proceeded with, and it is hoped will be completed during next year. One other series of this quadrilateral remains; but as the field work is not yet complete it cannot be taken in hand at present.

(3) In the Southern Trigon Colonel Lambton's triangulation has been under treatment, in order to reduce it to final terms; it forms a very extensive network, and though good progress has been made with it, a great deal yet remains to be done. All the secondary triangulation appertaining to the South Konkan Meridional Series has been finally reduced.

(4) The Latitude observations taken during 1886-87 by Lieutenant Burrard, R.E., have been reduced, the services of two computers having been lent to the Astronomical Party for this purpose.

(5) Two computers were also lent to the officer in charge of No. 14 Party (Mirzapur) for nearly three months to enable him to bring up the arrears of the Khándesh Topographical Survey.

(6) One computer has been placed at the disposal of Major Gore, R.E., for ten months, to aid in the computations of the Afghan Boundary Survey.

(7) Several tables for the new edition of Auxiliary Tables to facilitate the calculations of the Survey of India were computed and others were examined.

The remainder of the work performed by the Computing Section was of a miscellaneous character.

CLASS 3, ACCOUNTS, RETURNS AND CORRESPONDENCE.—Under this heading are included indents, estimates, monthly detailed and abstract progress reports, stock returns of Ordnance stores, the compilation of data for the Annual Report and various other items. The assistance rendered in the current work of the Deputy Surveyor General's office is also included in this class.

CLASS 4, SUPPLY.—Requisitions from seventeen officers for data of various kinds have been complied with. In this class is also included the cost of labour in the despatch of maps, charts, books and forms.

CLASS 5, PREPARATION OF PRESS COPY.—This consists in the writing of the letter-press for the several publications; and also in abstracting and compiling the results of the several calculations in a suitable form for publication. All tabular data when so compiled are carefully compared twice before handing to the printer. The details of the work are as follows:—

Southern Trigon.—The Introductions to three series were revised and completed; the synopses of latitude, longitude, and azimuth of seven series were recompared; the final examination of a portion of the Appendix on Lambton's triangulation, written by Lieutenant Burrard, was completed. The above are for the Professional Volumes. For the Synoptical Volumes of this section of the triangulation, only the data of the South Konkan Meridional Series were sufficiently advanced for a compilation to be made. The whole of the secondary triangulation of the Trigon has been divided up, and a suitable share assigned to each series; and the data for a second Synoptical Volume has been put in hand.

South-Wst Quadrilateral.—The compilation of the details of the principal triangulation of this Quadrilateral, with the exception of the heights, is complete, and the data have undergone comparison. The compilation of the abstracts of the heights is partly finished.

North-West Quadrilateral.—The compilation of the Synoptical Volume of the Jodhpore and Eastern Sind Series was completed and the volume has been printed and published. The whole of the triangulation, both principal and secondary, of the North-West Quadrilateral has now been finally disposed of and published.

Observed Latitudes.—The compilation of the details of the Latitude Volume have been completed and the introductory chapters have been written. Good progress in the printing of both has been made.

Longitude Operations.—After the manuscript for the new Volume of Longitude operations (Vol. X) was made over to this office, it was found in course of examination of the press proof that the manuscript could not be relied on as altogether errorless, and a good deal of examination of details had to be made while the pages were passing through the press. Moreover, 38 pages of appendix were also examined.

Spirit-levelling Operations.—The Pamphlet of Heights, No. 2 Madras Presidency, was examined and passed for the press, and the printing all but completed before the expiration of the Survey year. It will shortly be issued.

Charts.—Letter-press data for the East Coast Series charts, Nos. 7, 8 and 9, were partly compiled and corrected.

Auxiliary Tables.—These tables have been finished and are now in course of issue.

CLASS 6, PRESS PROOFS.—The work done under this heading relates entirely to the Printing Section. It consists of the examination and comparison of proofs. As most of

the matter printed is numerical or depends on numerical data, this examination can only be performed by men thoroughly acquainted with all the details of the subject in hand. Ordinary press readers could not be expected to render the critical examination which such matter requires. The charge for this class, though shown against the Computing Section, in order to balance the cost is debited against the Printing Section. Should the cost of the two sections be combined, this sum (R3,421) should be deducted from the total.

CLASS 7, CHARTS.—The careful examination of all charts of triangulation and of spirit-levelled heights before publication, is a matter of very great importance, and this work is also performed by the Computing Section, where the familiarity with the original records renders the detection of mistakes much easier and more certain than if the examination was made by the draftsmen themselves. All the charts, diagrams, &c., prepared during the year by the Drawing Section for the publications of the office were so examined; among them may be especially noted the East Coast Series charts Nos. 4, 5, 8 and 9, the final chart of the Eastern Sind Series, the Assam Longitudinal Series Degree Sheets 25 to 28 for the Synoptical Volume, besides which several other charts and diagrams were examined.

CLASS 9, MISCELLANEOUS.—In this class are included several duties of the Computing Section which cannot fairly be assigned to any of the other classes, such as the following:—The current observatory work at Dehra, the rating of chronometers; the cleaning and keeping in order of instruments of the larger class, &c.; the taking and reducing of time observations at Mussooree in order to give the time for the 12-o'clock gun; the reduction of the experimental base-line measured at Dehra last year; the adjustment of heights observed by Captain Jennings in Persia; the reduction of heights observed by Colonel Woodthorpe in Gilgit and beyond; the comparison against standard 4246, and determination of errors of the thermometers in use and in store in the office; and many other duties including the examination of two candidates for the Junior Division.

CLASS 10, METEOROLOGY AND GENERAL SCIENCE.—Deep sunk earth thermometers have been in use for some years; they were placed in holes sunk in a rather primitive fashion. One, the deepest, had caved in during a rainy season and the next to it had suffered in consequence. The other holes had also become large cavities in course of time. Four thermometers were re-set in holes lined with earthenware pipes 4 inches in diameter, *viz.*, at depths of 25·6, 12·8, 6·4 and 3·2 feet. Thermometers have also been retained in two of the old holes, *viz.*, the 12·8 feet, and 6·4 feet, for the sake of comparison; and though at first differences showed themselves, the temperatures of the corresponding thermometers settled down in September to very near identity, but they have begun to separate again since, the temperatures in the old holes being irregular, as was to be expected; especially as the new holes are provided with pads at intervals to stop convection currents, while the old ones being large and irregular cavities, nothing can be done to prevent these currents. An explorer and his assistant were instructed in the use of certain instruments and Mr. Dalgleish's latitude observations in Eastern Turkestan and Mongolia were reduced.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Mean Monthly Readings of Earth Thermometers.

Depth in feet of thermometer bulbs below surface of ground.	Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
		°	°	°	°	°	°	°	°	°	°	°	°
25·6	1881	...	...	...	...	...	73·55	73·90	75·02	76·07	76·69	76·98	76·71*
	1882	75·91	75·13	74·52	74·11	73·97	74·05	74·31	74·98	75·69	76·14	76·39	76·37
	1883	75·85	75·02	74·28	73·89	73·97	73·96	74·32	74·90	75·66	76·16	76·28	76·12
	1884	75·20	74·39	73·90	73·64	73·65	73·95	74·34	76·00	76·87	77·33	†77·27	76·72
	1885	75·83	74·95	74·34	74·00	73·92	74·02	74·25	‡	‡	‡	‡	‡
	1886	+	+	+	+	+	‡	‡	‡	‡	‡	‡	‡
	1887	(a) 74·58	74·67	74·30	73·80	73·50	73·55	73·95	75·05	76·01	...	...	...
12·8	1881	...	...	...	...	...	74·87	76·47	77·88	78·98	79·26	77·78	74·89
	1882	72·33	70·79	70·47	71·70	73·37	75·23	76·87	78·20	78·98	79·02	77·64	74·89
	1883	72·46	70·36	69·83	70·94	73·00	75·17	76·82	78·20	78·97	78·93	76·93	73·50
	1884	70·93	69·75	70·04	71·47	73·39	75·75	77·42	79·24	79·82	79·34	§77·08	74·52
	1885	72·18	70·37	70·03	71·14	72·66	73·99	76·09	78·98	79·42	79·25	77·93	75·36
	1886	72·49	670·56	70·26	70·95	72·46	74·12	76·18	78·63	79·54	79·41	77·82	75·16
(Old)	1887	(c) 72·56	68·80	69·67	71·12	73·38	76·09	77·65	79·23	79·77	...	...	...
(New)	1887	(d) 69·22	70·87	70·18	70·97	72·87	75·37	77·20	78·94	79·58	...	...	...
6·4	1881	...	...	...	...	...	80·66	81·01	80·75	81·24	80·33	75·80	70·58
	1882	67·17	66·06	67·77	72·29	76·47	80·01	80·78	81·30	81·32	80·16	75·75	71·03
	1883	67·64	65·10	66·48	71·00	76·72	79·29	80·70	81·42	81·12	79·50	74·56	68·71
	1884	66·03	65·61	67·95	72·36	76·99	80·76	81·46	81·61	81·10	78·85	73·81	69·57
	1885	66·64	64·83	66·73	71·10	74·29	77·59	80·32	80·77	80·85	79·90	76·19	70·97
	1886	66·53	64·72	66·61	69·99	74·87	77·87	80·34	81·54	81·70	79·92	75·50	70·69
(Old) ¶	1887	65·79	64·16	67·63	71·40	76·96	80·23	80·57	81·08	80·89	...	...	...
(New)	1887	(e) 64·65	64·54	67·58	71·72	77·91	80·94	80·86	81·11	80·88	...	...	...
3·2	1881	...	...	...	...	...	85·93	83·29	82·03	82·40	79·67	72·20	65·59
	1882	62·57	62·31	67·61	75·49	80·86	84·77	82·71	83·04	82·20	79·21	71·73	66·14
	1883	62·27	60·70	64·83	74·13	81·57	83·44	83·00	83·43	81·74	78·23	69·72	62·50
	1884	61·23	61·90	67·69	75·75	82·32	85·11	84·20	81·94	81·38	76·50	69·32	64·18
	1885	61·38	60·28	65·97	73·52	76·30	82·30	82·68	80·94	81·35	78·73	72·55	65·37
	1886	60·79	60·22	65·33	72·39	78·89	82·14	82·55	82·48	82·37	78·44	71·74	65·56
(New)	1887	(f) 61·70	59·99	68·80	76·55	85·47	84·93	82·56	81·63	81·31	...	...	...
		58·57											
1·1	1881	...	...	...	...	...	89·26	84·14	82·55	83·19	77·81	67·81	60·72
	1882	58·91	59·41	69·50	78·88	84·99	88·24	83·48	84·08	82·89	77·85	67·96	62·17
	1883	57·98	58·45	65·87	79·53	86·65	87·94	84·55	84·89	82·19	76·70	65·41	57·83
	1884	58·28	59·89	69·56	80·14	88·27	88·57	85·59	82·03	81·64	74·14	65·38	60·10
	1885	57·35	57·75	68·28	77·20	78·63	87·22	84·32	81·16	82·09	73·45	69·03	60·92
	1886	57·13	57·76	66·25	77·19	83·02	86·44	83·78	82·99	83·16	76·78	68·36	61·20
	1887	55·80	58·16	69·27	79·12	89·25	85·94	82·73	81·34	81·01	...	...	...
Thermometer in Shade.	1881	...	...	...	...	...	87·68	82·54	81·00	82·86	82·72	75·22	71·19
	1882	66·77	66·51	81·36	88·72	91·04	89·11	81·61	82·40	84·62	83·47	75·04	72·36
	1883	64·80	68·72	75·89	91·83	95·54	90·60	83·54	83·85	82·86	82·00	70·95	66·12
	1884	67·36	68·52	81·32	89·51	97·33	89·69	83·86	79·73	80·30	77·30	71·77	67·37
	1885	62·50	65·44	79·35	85·63	84·47	91·97	82·74	79·08	82·41	81·98	75·09	66·31
	1886	63·04	67·49	73·74	88·55	87·82	90·60	82·35	81·75	85·05	80·90	74·56	68·93
	1887	59·79	70·64	80·37	89·88	98·66	89·09	81·28	78·60	83·34	...	...	...

* The hole which had gradually filled up about 2½ feet, was dug down to the original depth between the 20th and 24th December 1881.

† The hole which had gradually filled up 2 feet since December 1881, was dug down to the original depth between the 9th and 18th November 1884.

‡ Earth fell in from the sides of the hole on the 2nd and 3rd August 1885; and covered the thermometer to the depth of 11 feet. It was found impossible to sink another thermometer to this depth till 20th January 1887, when a new hole was dug down to the depth of 25·6 feet and lined with 4-inch stoneware pipes.

(a) This is the mean of the readings of the last 11 days of the month.

§ The hole which had gradually filled up 11 inches since June 1881, was dug down to the original depth on the 17th and 18th November 1884.

(b) When the 25-foot hole filled up in August 1885, the 12-foot hole, which was close by, deepened about a foot, and the length of chain being greater than necessary, the thermometer remained suspended at a depth of 14 feet till 23rd January 1887, when the hole was filled up till it was only 12·8 feet deep. At the same time a new hole was dug to this depth and lined with 4-inch stoneware pipes. Readings from both have been regularly taken for the sake of comparison.

(c) This is the mean of the readings of a 14-feet deep thermometer for the first 23 days of the month.

(d) This is the mean of the readings of a 12·8 feet deep thermometer on the last 7 days of the month.

¶ A new hole was dug in January 1887 and lined with stoneware pipes, but the old hole was left undisturbed for the sake of comparing the readings.

(e) This is the mean of the readings of the last 7 days of the month.

(f) This is the mean of the readings of the first 13 days of the month, after which a new hole was sunk lined with 4-inch stoneware piping, and the reading below is for the last 14 days of the month.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Mean Velocity in Miles of the Winds which blew at Dehra Dún during the Twelve Months of 1886-87 for each Hour of the Day.

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	3·21	2·41	2·26	1·16	2·00	2·52	2·63	1·58	1·57	0·68	0·54	1·17
1 „ 2	2·48	2·10	2·06	0·97	1·96	2·35	2·50	1·61	1·43	0·52	0·50	1·10
2 „ 3	2·27	1·79	1·71	0·87	2·04	2·45	2·13	2·19	1·30	0·23	0·61	1·07
3 „ 4	1·93	1·76	1·90	1·00	1·38	1·71	1·67	1·61	1·33	0·23	0·50	1·41
4 „ 5	1·83	1·34	1·35	1·03	1·96	1·48	1·77	1·42	1·10	0·60	0·21	0·69
5 „ 6	1·86	1·52	1·52	0·77	1·80	1·45	1·53	1·55	1·13	0·77	0·11	0·69
6 „ 7	1·59	1·07	1·55	0·74	1·80	1·00	1·17	0·87	0·97	0·80	0·14	0·62
7 „ 8	1·24	0·71	1·61	0·84	1·76	0·94	1·10	1·03	1·57	0·53	0·21	0·76
8 „ 9	1·38	0·79	1·26	0·97	1·20	1·00	1·50	1·74	1·43	0·67	0·57	0·55
9 „ 10	2·17	1·11	1·29	1·23	1·60	1·94	2·37	3·00	1·90	1·40	1·00	1·45
10 „ 11	1·93	2·10	1·84	1·58	1·88	3·00	3·13	3·35	2·00	1·40	1·21	1·47
11 „ 12	2·69	2·31	2·29	1·68	2·52	4·26	4·27	4·19	1·97	1·30	1·21	1·57
12 „ 13	2·39	2·48	2·61	2·10	3·08	4·42	4·43	3·94	2·57	1·52	1·26	1·90
13 „ 14	2·75	2·72	2·52	2·52	3·24	4·52	4·30	5·06	2·70	1·94	1·85	2·14
14 „ 15	2·71	2·07	2·26	2·10	3·32	4·55	4·97	4·90	3·27	2·10	1·78	2·31
15 „ 16	2·39	2·21	2·06	2·03	3·08	4·61	4·53	4·77	3·13	1·81	1·74	2·28
16 „ 17	1·10	1·10	1·29	1·68	2·65	3·71	4·10	5·03	2·57	1·32	1·30	1·97
17 „ 18	0·69	0·41	0·61	0·87	1·77	2·81	3·13	3·32	2·23	1·10	0·78	0·55
18 „ 19	1·31	1·14	1·26	0·71	0·50	1·61	2·00	2·42	1·47	0·65	0·70	0·48
19 „ 20	2·48	1·97	2·03	0·61	1·00	1·55	2·07	1·48	1·27	0·26	0·30	0·79
20 „ 21	2·76	2·59	2·00	0·81	1·50	2·13	2·23	1·35	1·50	0·29	0·67	1·07
21 „ 22	2·83	2·90	2·52	1·06	2·62	2·45	2·67	1·97	1·90	0·35	0·63	0·90
22 „ 23	3·24	3·00	2·35	1·06	2·38	2·52	2·27	1·77	1·50	0·68	0·44	0·79
23 „ 24	2·86	2·55	2·42	1·06	1·96	2·81	2·47	1·90	1·80	0·48	0·85	1·03
Sums	52·09	44·15	44·57	29·45	49·00	61·79	64·94	62·05	43·61	21·63	19·11	28·76
Average	2·17	1·84	1·86	1·23	2·04	2·57	2·71	2·59	1·82	0·90	0·80	1·20

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Monthly Meteorological Results taken from the

Year and Month.	Barometer reduced to 32° Fahrenheit.						Hygrometer.			
	At 9-30 A.M.			At 3-30 P.M.			At 9-30 A.M.		At 3-30 P.M.	
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean temperature of dew point.	Monthly mean humidity.	Monthly mean temperature of dew point.	Monthly mean humidity.
1886.										
October	27·787	27·591	27·698	27·718	27·503	27·604	61·9	·668	62·1	·568
November	·926	·705	·810	·838	·621	·716	52·1	·677	53·2	·572
December	·938	·752	·829	·867	·681	·748	44·7	·651	45·8	·489
1887.										
January	27·833	27·521	27·700	27·747	27·458	27·622	45·6	·807	46·0	·626
February	·943	·572	·740	·863	·469	·661	42·2	·593	42·2	·379
March	·742	·467	·638	·636	·366	·550	46·0	·470	44·4	·312
April	·700	·476	·607	·630	·351	·518	49·5	·857	46·9	·266
May	·711	·362	·588	·571	·258	·382	56·3	·342	53·1	·243
June	·492	·312	·423	·466	·223	·332	66·8	·593	65·9	·492
July	·574	·270	·400	·450	·193	·328	73·9	·857	75·2	·819
August	·540	·337	·449	·480	·290	·389	73·4	·874	74·6	·859
September	·632	·404	·534	·574	·312	·456	69·2	·786	70·3	·700

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Register at the Trigonometrical Branch Office, Dehra Dún.

THERMOMETER.								RAIN.		WIND.	CLOUD.	
DRY BULB.					WET BULB.							
Maximum in sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum in wet.	Minimum in wet.	Monthly mean wet.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 9-30 A.M.	At 3-30 P.M.
148·0	44·7	85·5	53·7	71·6	74·5	47·6	63·3	5	3·76	N. E.	1	2
135·4	36·9	77·5	44·5	63·6	64·7	40·6	55·3	1	0·03	S. W.	1	2
127·4	35·3	72·7	41·0	57·6	59·5	38·9	49·9	2	0·99	W. S. W.	3	3
126·4	30·7	68·5	36·2	52·6	57·9	35·3	47·5	10	2·93	W.	6	7
135·1	27·4	78·3	35·7	59·0	64·2	33·7	49·4	1	0·34	W. S. W.	2	3
144·8	46·0	85·3	49·2	68·0	66·4	43·0	54·9	3	0·08	W.	4	4
156·9	44·9	99·5	54·1	77·0	68·9	47·2	60·0	2	0·17	N. W.	2	2
158·1	55·6	102·8	64·4	86·5	77·3	55·0	66·2	1	0·37	S. W.	...	1
154·0	61·8	99·7	60·8	82·2	82·1	61·2	71·4	13	10·49	Calm.	3	4
156·4	66·8	90·7	70·1	79·1	83·1	69·5	76·3	26	32·97	Calm.	8	8
158·5	66·9	86·9	69·8	77·5	81·6	69·3	75·7	28	30·27	Calm.	9	9
158·1	57·7	87·8	63·7	75·9	80·5	60·9	71·7	10	4·88	Calm.	3	5

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

TYPE PRINTING SECTION.—With the exception of a little work done for the Forest Department, the energies of this office have been almost entirely devoted to the printing of volumes of the Account of the operations of the G. T. Survey, of Synoptical Volumes of the Levelling operations and of the new edition of the Auxiliary Tables. Very satisfactory progress has been made during the year with the volumes of the Department.

Statement of Expenditure (Dr.) and Amounts credited (Cr.) on account of the Type Printing Section during the year 1886-87.

DR.			CR.		
	R	R		R	R
Superintendence	960		Letter-press, forms, diagrams, &c., for the Survey of India Department	13,784	13,784
Establishment	7,769				
Aid rendered by Computing Section	3,421				
Wear and tear of plant	612				
Contingencies	96	12,858			
Stores received from England	127	127			
Stores purchased in India	59		Miscellaneous letter-press, &c., extra departmental	95	95
Stationery from Stationery Office	835	894			
TOTAL	...	13,879	TOTAL	...	13,879

Statement of departmental work done by the Type Printing Section during the year 1886-87.

Specification of print.	No. of pages.	Total No. of pulls.	No. of copies.*	Value.
				R
Professional Volumes	593	113,154	510	8,698
Synoptical "	111	21,306	360	1,489
Pamphlets of spirit-levelled heights	70	5,287	510	582
Letter-press for charts, map headings and foot-notes	134	5,085	30	476
Auxiliary Tables	95	30,970	1,012	1,504
Forms	43	9,815	150	349
Explorations	19	1,144	110	101
Miscellaneous work done for the Trigonometrical Branch	107	25,561	80	525
TOTAL	1,172†	212,322	...	13,784

* Approximate number. † Equal to 1,464 pages of standard (foolscap) size.

Statement showing the amount and value of work done for other Departments by the Type Printing Section during the year 1886-87.

Name of other Departments.	No. of pages.	Total No. of pulls.	No. of copies.	Value.
				R
Forest Department	36	2,945	...	95
TOTAL	36*	2,945	...	95

* Equal to 31 pages of standard (foolscap) size.

The usual table showing the work annually performed by this section during the past five years is given below, the unit (a page of foolscap) being the same throughout. It will be observed that the out-turn of the past year is largely in excess of any previous one:

	1882-83.	1883-84.	1884-85.	1885-86.	1886-87.
Pages composed	1,381	1,489	1,505	1,340	1,516
Pages printed	475,586	362,386	470,970	638,593	805,076

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

An analysis of the pages composed is as follows :—

		PAGES
Professional	Longitude operations	500
	Latitude operations	291
	Great Arc Series, section 8° to 18°	90
	South-East Coast and Ceylon Series	6
	Madras Meridional and Coast Series	6
	Mangalore Meridional Series	12
	Appendix to Southern Trigon Volumes	24
	Bombay Longitudinal	21
	TOTAL	950
Synoptical	Jodhpur and Eastern Sind Meridional Series	121
	Madras Meridional and Coast Series	15
	Madras Longitudinal Series	9
	Bombay Longitudinal Series	6
	TOTAL	151
Miscellaneous	Spirit-levelled Heights, No. 2, Madras Presidency	67
	Letter-press for chart headings and foot-notes	92
	Auxiliary Tables	140
	Orders, Memoranda, Forms, &c.	57
	For Forest Department	31
	Explorations (M—H's)	28
	TOTAL	415

DRAWING SECTION.—The time of the office has been largely taken up in affording aid to Major Gore in the execution of trans-frontier maps required by the Government of India, and the regular work has therefore been a good deal in abeyance. Four charts of levels in the Punjab were in hand during the year; three were published, but large additions by the canal authorities necessitate a new edition of two of them, which is in hand. These level charts, which exhibit the operations of this Department, the Department of Public Works, and Railway Companies, all reduced to mean sea-level, are of great value, and it is a matter of regret that more progress cannot be made with them. Some final charts of triangulation have been prepared to illustrate Synoptical Volumes and also some charts of the work executed by the Coast Triangulation Party. The data on these charts are in final terms. A sketch map of explorer M—H's route has been published, and a set of charts of Himalayan snow peaks was constructed for the Australian Geographical Society. Mr. Carey's route from Khotan *viâ* Kurla to Hami, &c., from a survey by Mr. Dalgleish (about 3,000 miles in length) was plotted and adjusted and a tracing supplied to Mr. Carey for the use of the Royal Geographical Society, London. Also a good deal of work of minor importance was done.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Drawing Section during the year 1886-87.

DR.			CR.		
	R	*R*		*R*	*R*
Superintendence	4,800		Maps, Charts, &c., for the Survey of India Department	40,577	
Establishment	37,602				40,577
Contingencies	213		Maps, &c., Extra-departmental	2,213	
		42,615			2,213
Stationery from Stationery Office	175				
		175			
TOTAL	...	42,790	TOTAL	...	42,790

Statement showing the value of work done for other Departments by the Drawing Section during the year 1886-87.

Name of other Departments.	Value.	REMARKS.
	R *a.*	
For Bengal Government	35 15	
„ Foreign Office	840 11	
„ Quartermaster-General	1,270 7	
„ Forest Department	48 2	
„ Marine „	18 2	
TOTAL	2,213 5	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Departmental work done in Drawing Section during the year 1886-87.

Title of Maps, &c.	Scale 1 inch=.	Remarks and Progress.
Final Charts of Triangulation.	Miles.	
Assam Longitudinal Series Degree Sheets Nos. 1 to 28 .	4	Suspended for preparation of additional data to be incorporated therein.
Jodhpore Meridional Series	4	For reduction to half scale published.
Eastern Sind Meridional Series	4	Ditto ditto.
Preliminary Charts.		
East Coast Series, Secondary Triangulation Charts, Nos. 4, 5, 6, 7, 8 and 9.	2	Nos 4, 8 and 9 published. Nos. 5, 6 and 7 in press.
Compilation.		
Sketch Map to illustrate the route of Explorer M—H from Dagmara Thana, *viâ* the Dudhkosi to Dingri and thence *viâ* Jonkha Jong and Kirong to Tirbenighât.	8	For reduction to half scale. Published.
Level Sheet No. 6, Second Edition	2	Published.
Ditto „ 81, ditto	2	In press.
Ditto „ 83, ditto	2	In course of preparation.
Ditto „ 88, ditto	2	Ditto ditto.
Chart to accompany Pamphlet of spirit-levelled Heights No. 1, Madras Presidency.	12	For reduction to half scale. Published.
Miscellaneous.		
Charts showing snowy peaks on the Himalayas from Assam to the Kunar river, comprising sheets Nos. 19-20-27-28 of North-West Trans-Frontier, Nos. 5-6-12-13, 7-14-15, 20-21-28-29 and 22-23-30-31 of North-East Trans-Frontier, and Nos. 1-2-5-6, 3-4-7-8, 9, 14-15-21-22 and 16-23 of Northern Trans-Frontier.	16	For Australian Geographical Society.
Prepared Zenith distance observation forms . . .	...	For Photozincography and Departmental use.
Prepared Forms P 43, P 44 A, P 44 B and P 25 . .	...	Ditto ditto.
Prepared Forms for computation of distance apart . .	...	Ditto ditto.
Prepared Diagram of personal equation between Major Strahan, Major Heaviside and Lieutenant Burrard for arcs of Longitude.	...	For General Report, 1885-86.
Prepared Monthly diagrams of conspicuous sun spots from October 1886 to September 1887.	...	Published in Survey Notes.
Prepared two plates of figures of the Madras Meridional and Coast Series.	6	Reduced to half scale for publication in Professional Volumes.
Corrected the Index to sheets of Kangra and Simla Hill States.	16	Published in Annual Report, 1885-86.
Coloured up to date Map of India showing progress of Imperial Surveys.	...	Ditto ditto.
Extracted notes from Prejevalsky's Travels in High Asia .	...	For record in office.
Copied a Report on Sikhim received from Quartermaster-General, 47 pages of quarto size Memo. Book.	...	Ditto.
Examined 442 proofs of Maps and Charts . . .	...	
Finished drawing of Degree Sheet VIII, comprising Nos. 38-39-53-54, 40-41-55-56 of Rajputana.	2	Published.
Finished Sheet No. 76 of Rajputana Survey . . .	1	Ditto.
Corrected Sheets Nos. 6 and 7 of Ajmere City Survey .	1½	Ditto.
Examined Sheets Nos. 200 S.E., 200 N.W., 200 N.E., and 201 S.E., of Mirzapur Survey.	½	
Examined and corrected Chart to accompany Pamphlet of spirit-levelled Heights No. 2 of Madras Presidency.	8	For reduction to half scale. Published.
Examined and corrected 4 maps and 1 chart of Triangulation of Nicobar Islands Survey.	2 & 5	In press.
Examined Indian Atlas Sheets Nos. 38 S.W. and 39 S.W.	...	
Maps coloured, No. of copies=5,057	...	
22 Maps for Surveyor General's Office	Various .	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement of extra-departmental work done by the Drawing Section during the year 1886-87.

Title of Map.	Scale 1 inch=	Remarks and Progress.
Compilation, Mapping, &c.	Miles.	
Copied boundary-line between Nepal and Darjeeling in Sheets Nos. 1, 2, 3 and 4 (Mechi river) of Nepal Boundary Survey	¼	For Deputy Commissioner, Darjeeling.
Prepared Triangulation Chart of India showing triangulation in the vicinity of the coast.	96	For the Superintendent, Marine Survey, Bombay.
Prepared a tracing of the map showing area affected by the Deoban-Chakrata Sledge Road.	½	For the Conservator of Forests, School Circle, Dehra.
Completed with respect to heading and foot-notes, Forest maps, before sending to press.	Various .	For Forest Department.
Made an extract from standard sheet No. 76 of Rajputana Topographical Survey.	1	For Officer on special duty, Sirohee Boundaries, Rajputana.
13 Maps for Foreign Office and Quartermaster-General's Office.	Various .	

Photozincographic Section.—This office has been employed in printing maps, charts, forms, diagrams, &c., both to illustrate the volumes published by the office and for general use; it has also executed a good deal of work for the Forest Department and a certain amount for the Foreign Office and Quartermaster-General's Department.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Photozincographic Section during the year 1886-87.

Dr.			Cr.		
	R	*R*		*R*	*R*
Superintendence	2,460		Maps, Forms, Diagrams, &c., for the Survey of India Department.	14,129	14,129
Establishment	8,603				
Contingencies	176	11,179			
Chemicals and Stores from England	2,925				
Paper received from England .	1,703	4,628			
Chemicals and Stores purchased in India .	418		Miscellaneous Maps, Plans, &c., Extra-departmental . . .	6,188	6,188
Stationery (paper) from Stationery Office	170	588			
Shipping and Landing charges .	50	50			
Balance to credit of Department .	...	3,872			
Total .	...	20,317	Total .	...	20,317

Note.—In addition to the credits above shown, the section has realized (by sale on payment of maps, &c.) and paid into the treasury the sum of R943-7-8.

Statement showing the amount and value of work done for the other Departments by the Photozincographic Section during the year 1886-87.

Names of other Departments.	Photozincographic Printing.						Type-printing.		No. of Pulls.	No. of Copies.	Value.	Remarks.
	No. of sheets or Sections or subjects.	No. of Negatives.	No. of Photo-transfer Prints.	No. of Zinc Plates.	No. of Silver Prints.	No. of Blue Prints.	No. of pages or Items.	No. of copies.				
											R a.	
Forest Department .	80	284	207	55	...	315	...	...	3,614	4,632	3,554 11	
Foreign Do. .	10	36	56	10	...	...	...	...	405	405	736 2	
War Office	25	8	161	...	...	161	...	...	...	52	138 0	
Quartermaster-General	34	112	68	13	69	...	...	...	2,586	2,901	1,638 13	
Chief Engineer, Khwaja-Amran State Railway . . .	3	12	8	...	12	20	...	...	1	3	.90 0	
Superintending Engineer . . .	2	...	...	...	...	16	...	...	...	2	.30 0	
Total .	154	452	500	78	81	512	...	...	6,606	7,995	6,187 10	

Statement of Departmental work done by the Photozincographic Section during the year 1886-87.

Specification of Plate or Print.	Photozincographic Printing.								Type-printing.		Total No. of pulls.	No. of copies.	Value		Remarks.
	Progress made.	Scale of maps.	Size of each sheet.	No. of sheets, sections or subjects.	No. of negatives.	No. of photo. transfer prints.	No. of zinc plates.	No. of silver prints.	No. of blue prints.	No. of pages or items.	No. of copies.				
		1 inch=												R	a.	
Plates IV, V, and VI	F.	Various	½	D.E.	3	6	12	2	...	...	...	...	650	1,300	175	0	For Professional Vol. X of Electro-telegraph Longitudes.
Plate 7 of the Great Arc Series	,,	2 and 12 miles.	½	,,	3	4	7	3	...	...	...	...	1,018	1,518	140	1	For Professional Volume of Southern Trigon.
Rajputana Topographical Survey Sheets Nos. 73, 74, 75 and 76	,,	1 mile		D.E.	4	6	6	4	...	...	...	...	303	303	145	15	
Do. Survey Degree Sheet No. VIII	,,	2 ,,		,,	2	12	12	2	...	...	...	...	306	306	239	14	
Abstract account of conspicuous Sun-spots for 9 months	,,	...	½	F.P.	9	9	48	9	...	...	...	...	941	1,882	233	12	For Survey of India Notes.
Index Map to the Nicobar Island Survey	,,	16 ,,	½	D.E.	1	2	2	1	...	...	...	...	36	36	37	5	
Nicobar Island Survey Sheet No. 1	,,	2 ,,		D.E.	1	8	8	1	...	...	...	...	50	50	121	2	
Do. do. Nos. 2 and 3	In Press.	2 ,,		,,	2	16	16	2	...	...	...	...	...	...	220	12	
Do. Map	,,	5 ,,		,,	1	8	...	1	...	...	...	...	...	...	45	9	
Do. Triangulation Chart	,,	2 ,,		,,	1	6	6	1	...	...	...	...	...	...	82	13	
Bhopal and Malwa Survey Triangulation Chart, Degree Sheet No. IX	F.	4 ,,		,,	1	6	12	2	...	...	...	...	33	33	143	13	
North-East Trans-Frontier Sheet No 5	,,	8 ,,		,,	1	6	6	1	...	...	...	...	60	60	99	5	
Northern do. do. Nos. 20 and 21	,,	8 ,,		,,	2	12	12	2	...	...	...	...	120	120	198	10	
Graticule Sheet, North Trans-Frontier; 24° to 28°	,,	16 ,,	*	,,	1	...	...	1	...	...	...	...	6	6	3	0	
Do. do. do. 34° to 36°	,,	8 ,,		,,	1	...	...	1	...	...	...	...	24	24	7	8	
Do. North-East do. 32° to 36°	,,	16 ,,		,,	1	...	...	1	...	...	...	...	12	12	6	0	
Do. North-West do. 38° to 40°	,,	8 ,,		,,	1	...	...	1	...	...	...	...	24	24	7	8	
Southern Waziristan; Preliminary issue	* ,,	2 ,,		,,	1	...	...	1	...	...	...	...	25	25	7	10	
Index to South-West Asia Sheets	* ,,	320 ,,	¼	,,	1	...	2	1	...	...	...	...	32	64	19	0	
Maps of the City of Jeypore, Nos. 1 to 8	* ,,	½ ,,		D.E.	8	...	...	16	...	...	...	...	800	400	122	0	
Table of Distances	,,	...	½	S.R.	6	3	12	1	...	...	...	...	50	50	96	13	
Gujarát Survey Sheet No. 50	,,	½ ,,	½	D.E.	1	2	...	...	2 pcs.	...	...	...	...	1	15	14	
Do. do. No. 49, Section 14	* ,,	¼ ,,		D.E.	1	...	6	1	...	...	...	...	12	12	54	10	Specimen copies.
Himalaya Peaks from Assam to the Kunar River	,,	16 ,,		...	10	16	76	10	...	...	...	...	100	100	714	10	For Australian Gregraphical Society.
Index to the Sheets of the Punjab Survey	,,	16 ,,	½	,,	1	8	16	3	...	...	...	...	542	542	196	11	For General Report, 1885-86.
Charts of Spirit-levelling operations Nos. 1 and 2	,,	24 and 16 miles.	D.E. and ½	D.E.	2	6	10	3	...	...	...	...	1,030	1,030	218	11	For Pamphlets of Spirit-levelled Heights, Nos. 1 and 2, Madras Presidency.
Level Chart Sheet No. 6 (2nd Edition)	,,	2 ,,		D.E.	1	6	6	1	...	...	...	...	110	100	107	12	
Do. do. No. 81 (do.)	In Press.	2 ,,		,,	1	6	...	1	...	...	...	...	...	...	34	3	
Do. Bench-marks (do.)	F.	...	½	,,	1	1	2	1	...	...	...	...	52	104	23	14	
Hyderabad Survey, Nos. 220 and 224	,,	1 mile		D.E.	2	...	12	2	...	...	...	...	155	155	134	10	
Diagram of North-West Quadrilateral	,,	64 ,,	½	,,	1	...	2	1	...	...	...	...	175	350	28	15	For Vol. VII A (Synoptical).
Do. Personal Equation	,,	...	½	,,	1	2	6	2	...	...	...	...	240	480	48	6	For General Report, 1885-86.
Skeleton Chart of principal chains of triangles, &c.	,,	280 miles	½	,,	1	½	4	1	...	...	...	...	120	480	46	0	Ditto.
Final Charts of Jodhpore Meridional Series, Nos. 1 and 2	,,	8 ,,		D.E and D.E.	2	16	16	2	...	...	...	...	910	910	325	15	
Do. Eastern Sind Meridional Series	,,	8 ,,		D.E.	1	9	9	1	...	...	...	...	375	375	169	12	For V. VII Alo (Synoptical).

Secondary Triangulation Charts of East Coast Series, Nos. 4, 8 and 9		2 ,,	,,	3	18	18	3	...	...	...	...	90	90	257	5	
Secondary Triangulation Charts of East Coast Series, Nos. 5, 6 and 7	In Press.	2 ,,	,,	3	24	...	3	...	...	...	...	...	...	136	11	
Madras Meridional and Coast Series, Plates 1 and 2	,,	12 ,,	½ ,,	2	2	8	2	...	...	...	...	...	...	61	12	For Professional Vol. of Southern Trigon.
Star Chart in four plates	F.	...	¼ D.E.	4	4	12	3	...	4	...	...	1,020	1,020	176	2	For new edition of Auxiliary Tables.
* Surat City, Cantonment and Environs, eastern half	,,	½ mile.	D.E.	1	...	...	...	...	...	...	...	54	54	25	10	
Mirzapur Survey Sheets, Nos. 200 N. W., 201 N. E., and 201 S.E.	,,	½ & 1 ,,	D.E. and ¼ D.E.	3	14	14	3	...	7	...	...	317	317	272	0	
Sketch map illustrating the route of explorer M—H	,,	16 mile.	½ D.E.	1	4	4	1	...	...	...	...	123	123	60	0	For Exploration Report.
Bangalore Cantonment and City in 13 Sheets	,,	12 ,,	D.E.	11	66	66	11	...	...	...	...	1,133	1,133	1,176	5	
Khándesh Survey Triangulation Chart Degree Sheets, Nos. III and VI	,,	4 ,,	,,	1	6	6	1	...	...	...	...	22	22	89	3	
* Country between Umballa and Delhi	,,	4 ,,	,,	1	...	8	1	...	...	...	...	25	25	72	7	
Ajmere City, Nos. 6 and 7	,,	12 ,,	,,	2	15	15	2	...	...	...	...	150	150	236	5	
* Kumaun and Garhwál Survey, Contour Sheet No. 14	,,	1 ,,	,,	1	...	10	...	...	...	...	...	...	2	45	0	
Index to Sheets of Punjab Survey, Simla Hill States	,,	...	½ ,,	...	1	3	...	...	3	...	...	...	3	11	3	
Miscellaneous Forms, &c., &c., for departmental use	,,	...	Various.	50	36	105	36	...	10	...	...	13,525	8,709	1,893	15	
Other maps for office use and for Surveyor-General's Office	,,	various.	,,	177	340	552	76	36	370	...	...	1,155	1,261	4,845	0	
Copies of Maps of other Departments taken for Departmental use.																
Forest Map of Chota-Nagpore Sheets Nos. 157 S.W./2, 157 S.W./4 and 157 S.W./2-R.	F.	¼ and 1 mile.	D.E. and ¼ D.E.	3	14	21	3	...	...	...	...	40	55	13	0	Copies retained, *for office record*, of maps, &c., requisitioned for by other departments; the cost of press pulls and stationery being all that is here charged to the Survey Department.
Forest Map, Kapurthala	,,	2 ,,	½ D.E.	1	1	4	1	...	...	...	...	5	20	2	10	
Chakráta-Deoban Sledge Road Map	,,	½ ,,	D.E.	1	6	6	1	...	...	...	...	15	15	6	6	
Berar Forest Survey, parts of Sheets Nos. 20 and 20A	,,	¼ ,,	D.E. and ½ D.E.	4	16	20	4	...	90	...	...	66	66	23	13	
Kalesar Reserved Forest Sheet No. 336	,,	¼ ,,	D.E.	1	9	9	1	...	30	...	...	20	20	6	10	
Kumaun and Garhwál Forest Survey Sheets Nos. XIV, XLHI and LXXVIII	,,	¼ ,,	,,	3	18	19	2	...	90	...	...	47	46	19	4	
Kumaun and Garhwál Forest Survey Sheets Nos. I, III A, III B, IV, V, XV, XVII to XXIII, XXV to XXVIII, XXXI, XXXII, XXXIV to XXXVIII	,,	¼ ,,	¼ ,,	24	60	60	16	...	60	...	...	211	390	49	15	
Kumaun and Garhwál Triangulation Chart No. II	,,	¼ ,,	D.E.	1	8	8	1	...	5	...	...	17	17	6	8	
Changa Manga Plantation Map	,,	¼ ,,	,,	1	7	7	1	...	...	...	...	16	16	6	8	
Purampur Reserved Forest	,,	1 ,,	,,	1	6	6	1	...	...	...	...	16	16	6	8	
Chir Forest on the Tons river	,,	1 ,,	½ ,,	1	4	4	1	...	...	...	...	15	15	3	6	
Tiri-Garhwál Leased Forests, Jaunsár Division	,,	¼ ,,	½ ,,	1	4	8	1	...	...	...	...	8	16	2	9	
Map of Jaunsár Forest Division	,,	4 ,,	½ ,,	1	4	4	1	...	...	...	...	16	16	3	5	
Dehra Dún and Saháranpur Forest Division	,,	4 ,,	½ ,,	1	...	4	1	...	...	...	...	20	20	3	7	
Map of Nindhaur Hills, Working Circle	,,	1 ,,	D.E.	1	8	8	1	...	...	...	...	15	15	6	6	
Do. Singhbhoom	,,	4 ,,	,,	1	4	4	1	...	...	...	...	20	20	3	14	
Appendix B, illustrating the system of working on a confidential route	,,	6 ,,	½ F.P.	1	...	2	1	...	...	...	...	10	20	1	7	
Ránikhet Cantonment and Environs	,,	8 ,,	D.E.	1	7	7	1	...	...	...	...	15	15	6	6	
Diagram, Indexes 2 and References 2	,,	...	½ ,,	5	2	4	2	...	40	...	...	10	50	1	12	
35 Other Maps	,,	Various.	D.E. and ½ D.E.	35	63	28	13	114	12	...	...	120	173	322	8	
TOTAL	...	...	...	425	948	1,350	279	152	721	...	...	26,627	24,792	14,129	2	

* Additional prints of previous publications.—D.E. represents Double Elephant; F. P. represents Foolscap; F. represents Finished; S.R. represents Super-royal.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

SOLAR PHOTOGRAPHIC SECTION.—This section comprises a photographer and four *khalásis;* the photographer has two photoheliios in his charge, one giving 8-inch pictures and the other 12-inch. With the former he has to take two negatives each day that the sun is visible except on Sundays, when he takes only one negative : with the latter he takes negatives when the sun shows any remarkable phenomena. During the year the sun was invisible on 61 days, and two other days were lost from illness of the photographer. Of the 302 days on which negatives were taken, the sun showed either spots or faculæ on 298, and only four days showed no features.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Solar Photographic Section during the year 1886-87.

Dr.	R	R		R	R
Superintendence	600		Value of Negatives and silver prints taken for the Solar Physics Committee, under authority from the Secretary of State for India (debitable to the Industry, Science and Art Departments).	4,494	4,494
Solar Photographer	1,347	-			
Establishment	234				
Contingencies	814				
		2,995			
Chemicals and Stores received from England.	1,261				
		1,261			
Chemicals and Stores purchased in India.	213				
		213			
Shipping and Landing charges	25				
		25			
TOTAL	...	4,494	TOTAL	...	4,494

Table of Working Facts for the year 1886-87.

1886-87.	Number of days.				Number of Negatives.										Number of working days when solar phenomena were	
		Failures.			Solar Phenomena.								Total.			
	When Negatives were taken.	From bad weather.	From various causes.	Total.	Spots and Faculæ.		Spots only.		Faculæ only.		None.				Visible.	Absent.
					8″	12″	8″	12″	8″	12″	8″	12″	8″	12″		
October	31	...	...	31	44	8	...	...	14	...	...	...	58	8	31	...
November	30	...	...	30	6	...	...	...	52	...	...	...	58	...	30	...
December	22	9	...	31	28	...	...	...	14	...	...	...	42	...	22	...
January	18	13	...	31	25	...	...	...	5	...	...	...	30	...	18	...
February	25	3	...	28	31	...	...	...	14	...	...	...	45	...	25	...
March	29	2	...	31	32	...	...	...	19	...	...	...	51	...	29	...
April	26	2	2	30	30	...	...	...	18	...	...	...	48	...	26	...
May	30	1	...	31	46	...	3	...	8	...	...	...	57	...	30	...
June	27	3	...	30	39	...	4	...	1	...	...	...	44	...	27	...
July	17	14	...	31	24	...	...	...	...	...	2	...	26	...	16	1
August	20	11	...	31	19	...	...	...	10	...	...	...	29	...	20	...
September	27	3	...	30	19	10	2	...	21	...	5	...	47	10	24	3
TOTAL	302	61	2	365	343	18	9	...	176	...	7	...	535	18	298	4

Total number of silver prints prepared during the year is 1,110.

Table of Percentages of daily visibility of the Sun and the presence of features.

Year.	In 100 days the sun was invisible on	In 100 days features were present on
1877-78	9 days (obtained from 273 days)	30 days (obtained from 248 working days).
1878-79	11 ,, ,, 89 ,,	28 ,, ,, 79 ,,
1879-80	14 ,, ,, 289 ,,	82 ,, ,, 232 ,,
1880-81	15 ,, ,, 365 ,,	96 ,, ,, 307 ,,
1881-82	10 ,, ,, 365 ,,	100 ,, ,, 328 ,,
1882-83	13 ,, ,, 365 ,,	100 ,, ,, 318 ,,
1883-84	21 ,, ,, 366 ,,	100 ,, ,, 285 ,,
1884-85	22 ,, ,, 365 ,,	100 ,, ,, 284 ,,
1885-86	21 ,, ,, 365 ,,	100 ,, ,, 290 ,,
1886-87	17 ,, ,, 365 ,,	98 ,, ,, 298 ,,

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Contrasting the percentages of days of invisibility above given with those for Greenwich, as furnished by the Astronomer Royal's Report, we have—

Year.	At Dehra, year ending 30th September.	At Greenwich.
1880-81	15	60 } Year ending 20th May.
1881-82	10	45
1882-83	13	45 } Year ending 31st December.
1883-84	21	41
1884-85	22	58
1885-86	21	
1886-87	17	

Government of India Central Printing Office.—No. 17 S. G.—24-4-88.—425.

Circular No. $\frac{61S.}{81—2}$

Extract from the Proceedings of the Government of India, in the Revenue and Agricultural Department (Surveys), dated Simla, the 26th June 1888.

READ—

The General Report on the Operations of the Survey of India Department for the year 1886-87.

RESOLUTION.

Personnel.

THE administration of the Department remained in the hands of Colonel H. R. Thuillier, R.E., who was confirmed in the appointment of Surveyor-General on the death of Colonel G. C. DePree in February 1887. The Revenue and Trigonometrical Branches continued to be under the superintendence, respectively, of Colonel J. Sconce, S.C., and Colonel C. T. Haig, R.E.

Number of parties.

2. The various operations were carried on by 25 different parties.

Secondary coast triangulation.

3. One party continued the secondary triangulation on the Coromandel Coast, carrying the chain of triangles from Madras to a distance of 170 miles, a little beyond Nellore. Owing to bad weather and sickness, the party did not succeed in continuing the triangulation northwards so as to unite with the operations of the previous year. A gap of 80 miles was thus left over for the following season.

Topographical surveys.

4. The number of topographical survey parties was reduced from ten in 1885-86 to eight in the year under report, the Cutch and Deccan parties having been transferred to the Central Provinces to take up the traverse surveys of districts coming under revision of settlement. Two out of the eight parties were employed partly on topographical and partly on Forest surveys in Bombay. A topographical section was, however, added to the cadastral party in Burma with the view of completing the topography of hill ranges in the Akyab District; and the Punjab traverse party also made some original surveys of portions of Native States. The two parties in Bombay, one party in Baluchistan, one in the Mirzapur District, North-Western Provinces, and one in the Himalayas, were employed in continuation of the operations of the preceding year. A second party was sent (from Rajputana) to Baluchistan to aid in the general survey of that country and for special survey work on the frontier required by the Military authorities. Another party was transferred to Madras from Mysore, and it took up the survey of the Madura and Tinnevelly districts. The area remaining to be topographically surveyed in that Presidency was, on the suggestion of the Government of India, made over to the Imperial Survey Department, with the view of accelerating the completion of revenue surveys in Madras by the Local Survey Department. The eighth topographical party made a survey of the Nicobar Islands, mainly with the object of meeting the requirements of navigation. A portion of the coast of the Little Andaman Island was also surveyed at the request of the Chief Commissioner of Port Blair.

The aggregate area topographically surveyed on various scales by all the parties amounted to 17,510 square miles, as compared with an outturn of 19,162 square miles surveyed in 1885-86 by ten parties.

Native soldiers were attached to the two Baluchistan, the Mirzapur and the Himalaya parties for training in survey work.

It may be explained that the reduction in the number of topographical survey parties to meet demands for revenue surveys is due to the fact that the

latter class of work cannot be postponed without entailing loss of State revenues, whereas topographical surveys, however useful, may be postponed without serious detriment to the administration.

Forest surveys.

5. The Forest surveys in Bombay were, as already mentioned, carried on by sections of two topographical survey parties. The areas surveyed lie partly in the Belgaum District, Southern Circle, and partly in the Thánd District, Northern Circle. In the Southern Circle, the work comprises the preparation of a skeleton map showing the survey of Forest boundaries, any details that are considered necessary being filled in afterwards by the Forest Department, whereas in the Northern Circle the Forest reserves have to be surveyed in full detail.

Two small forests in the Gorakhpur District, North-Western Provinces, were surveyed by the cadastral survey party employed there.

The Forest survey party in Burma was unable to continue its work in the Prome District on account of the unsettled state of that part of the country. Two European Surveyors and a few sub-surveyors were sent to Upper Burma, and the remainder of the party was transferred to the Zamayi Forests, Pegu District, where preliminary triangulation and traversing constituted the chief work. The outturn of final survey was very small.

Cadastral surveys.

6. Five out of six cadastral survey parties continued with little change the operations of previous years. They were employed in (1) the Bilaspur and Raipur districts, Central Provinces; (2) in the Basti; and (3) the Gorakhpur and Tarai districts, of the North-Western Provinces; (4) in the Darrang and Nowgong districts, Assam; and (5) in the Akyab, Bassein and Thongwa districts, Burma. The sixth party was divided into three Sections, two of which were engaged in Bengal, on the cadastral survey respectively, of the Sankarpur Wards' State, Dinagepore District, and the Government Estate of Angul, Orissa District. The third section took up the survey of the town of Calcutta, which comprises the survey of boundaries of separate properties paying revenue to Government in addition to the ordinary particulars concerning streets and houses, and the collection of information regarding owners of properties required for the Calcutta Collectorate.

There was a slight interruption in the progress of cadastral survey operations in the Bilaspur District owing to the partial scarcity caused by the failure of autumn crops in 1886. Two detachments from Bilaspur party were therefore sent to Raipur. The total outturn of survey work was, notwithstanding, 259 square miles more, and the average cost Rs. 36-13 per square mile less, as compared with the previous year. The average cost of operations in the Basti District increased during the year under report by Rs. 40-8-10 per square mile. This is accounted for by the unprecedented and extremely minute sub-division of property met with, the average size of fields being 0·27 of an acre. With the view of affecting a speedy completion of the cadastral survey of Gorakhpur, the party employed therein was enlarged, resulting in a larger outturn of work and a diminution of the cost per square mile. The experiment of employing Patwaris as surveyors in place of amins was tried during the year for the first time in the Tarai District. The Patwaris showed dissatisfaction at first, and it was difficult to train the men; but the plan proved successful in the end, and it is reported that some excellent work was turned out.

Traverse surveys.

7. Traverse surveys were continued by one party in the Gurdaspur, Gujranwala and Shahpur districts of the Punjab, and by five parties in the Raipur Jubbulpore-Damoh, Seoni-Chhindwara, Saugor-Narsingpur and Sambalpur districts of the Central Provinces. The total areas traversed are 6,085 square miles in the Punjab and 10,576 square miles in the Central Provinces. Some outlying portions of Sikh States were surveyed by the Punjab party with the view of completing the topographical maps of that part of the country. A special survey was also made in the Gurdaspur District bordering on Kashmir territory, for the purpose of settling a dispute between British and Kashmir cultivators

as regards the rights to water from irrigation channels. It is satisfactory to notice that the cost of traverse surveys in the Raipur District, Central Provinces, was reduced so low as Rs. 19-7 per square mile.

Geodetic.

8. As only one officer was available for the superintendence of Astronomical work, the telegraphic longitude operations were suspended. The latitude observations were extended to the south of Jubbulpore and observations completed at five stations.

Tidal and levelling operations.

9. Observations for registration of Tides were taken at 17 ports in India, Burma, the Andamans, Ceylon and Aden. A new Tidal Observatory was established at Akyab, while that at Dublat, near the mouth of the Hooghly, was swept away by a cyclone in September 1886. The spirit-levelling operations consisted of six sections; (1) from Tuticorin to Madura; (2) from Madura to Trichinopoly and Tanjore; (3) from Trichinopoly to Erode; (4) from Shoranur to Cochin Tidal Station; (5) from Kárwár Tidal Station to Marmagao and (6) from Agoada Fort Jetty to Agoada. The heights of 418 permanent bench marks and of 6 stations of the Great Trigonometrical Survey were finally determined.

Geographical surveys in Upper Burma.

10. Two detachments, one of which was supplemented by a section of the Forest survey party on the suspension of work in the Prome District, were employed on geographical surveys in Upper Burma. One of these detachments under Major Hobday completed the reconnaissance surveys of an aggregate area of 11,000 square miles lying partly in the Shan States and the Ruby Mines District, partly in the Yaw country and partly in the Yemethin, Mehtilla, Mandalay and Kyaukse districts. The survey of the town of Mandalay was also continued. The second detachment, under Colonel Woodthorpe, accompanied the Military expedition that proceeded from Manipur to the Chindwin District. Colonel Woodthorpe, with his assistant Mr. Ogle, succeeded in carrying the triangulation connected with the main series of India from Manipur to the Chindwin District.

Trans-Himalayan Explorations.

11. An account of the explorations in Nepal and Thibet by explorer M. H. has been separately published, illustrated by a map of the routes; and appended to the report under review are Notes by Colonel H. C. Tanner with sketch maps of explorations in Bhutan and on the Sangpo river, made respectively by explorers R. N. and K. P. The latter went into Thibet in the year 1880 in company with a Chinese láma. Explorer K. P. was sold as a slave in the Pemakoi country, and managing to escape has returned with information, which, combined with an account given by a Mongolian láma, has enabled Colonel Tanner to construct an amended chart of the Sangpo river.

Head-Quarters offices, Calcutta.

12. The progress of work in the Head-Quarters offices at Calcutta was satisfactory. The number of maps published amounted to 4,158, of which 3,843 were cadastral maps. 178,398 maps, valued at Rs. 1,36,344, were issued; and the income from map sales amounted to Rs. 9,254. Owing to the contraction of cadastral and topographical surveys, and the employment of a larger number of field parties on traverse surveys, the number of original maps received for reproduction by photography was much below the average.

The work of the Drawing office has greatly increased in connection with the mapping of surveys and reconnaissances of the Afghan Boundary Commission and by urgent demands for maps of Burma and Baluchistan. A new edition of the map of India on the large scale of 32 miles to the inch has been taken in hand, and it is also proposed to prepare an outline map on the same scale, which will be useful for representing lines of railway, canals, &c.

Experiments were continued with the view of introducing the aid of photography for reproducing the Indian Atlas sheets in lieu of hand-engraving. Reproduction by photozincography has proved a failure, but the experiment of first photographing the map from a manuscript drawing and then transferring it to

copper by the photo-electrotype process, shows that this method is well adapted to take the place of hand-engraving for maps required for temporary use and which are likely to be superseded by later editions.

The heliogravure processes have been utilized largely for the reproduction of drawings for the Archæological survey and for a technical art series. In the appendix are specimens of collotype printing.

36,969 mathematical instruments valued at Rs. 1,91,183 were added to the serviceable stock, and 37,391 serviceable instruments valued at Rs. 1,83,519 were issued on indent.

Dehra office.

13. The work of the computing branch of the office at Dehra made satisfactory progress, and several publications containing results of the final reduction of operations of the Great Trigonometrical Survey were made.

ORDER.—Ordered, that the above Resolution be forwarded to the Local Governments and Administrations noted on the margin, to the Surveyor-General of India, and to the Foreign and Military Departments, for information. Ordered also, that the Resolution be published in the *Gazette of India*.

Madras.
Bombay.
Bengal.
N.-W. P. and Oudh.
Punjab.
Central Provinces.
Burma.
Assam.
Coorg.

(True extract.)

E. C. BUCK,

Secretary to the Government of India.

FILE No. 81.
SERIAL No. 2.

No.

1888.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEY.

RESOLUTION.

Circular No. 61S. / 81—2

Dated Simla, the 26th June 1888.

SUBJECT:

Remarks on the General Report on the operations of the Survey of India Department for the year 1886-87.

G. C. Press, Simla.—No. 128 R. & A. D.—30-6-88.—175.

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on 01 February, 2020